THE

FOUNDRY TRADE JOURNAL

WITH WHICH IS INCORPORATED

THE IRON AND STEEL TRADES JOURNAL

VOL. 51 Thursday, July 5, 1934 No. 933

PUBLISHED WEEKLY.

Subscription Terms: 15s. per annum.
Foreign and Colonial: 17s. 6d. per annum.
All Subscriptions are payable in advance.

All Communications to be addressed to the Editor, the Advertisement Manager, or the Publisher of

THE FOUNDRY TRADE JOURNAL,
49, WELLINGTON STREET, LONDON, W.C.2

Telegraphic Address: "Zacatecas, Rand, London."
Telephone: Temple Bar 3951 (5 lines).

THE FOUNDRY TRADE JOURNAL IS THE OFFICIAL ORGAN OF

The Institute of British Foundrymen
The Institute of Vitreous Enamellers
The National Ironfounding Employers' Federation
The Welsh Engineers' and Founders' Association
and
The Foundry Trades' Equipment and Supplies Association

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Contents

	PAGE
Some Laboratory Inspections	1
Satisfaction Clause in Contracts of Sale	1
Correspondence	2
The Institute of British Foundrymen	2, 14
Catalogue Received	2
Random Shots	2
Notes Around the Branches	2
On the Use of High-Duty Cast Iron in the Manufacture of Textile Machinery	3
Non-Ferrous Foundry Practice	5
Contribution to the Study of Graphite Formation and Structure in Cast Iron and its Influence upon the Properties of the Cast Metal	7
This Week's News in Brief	16
Trade Talk	16
Contracts Open	16
Company Reports	16
New Companies	16
Personal	16
Company Meeting	16
Obituary	16
Raw Material Markets	18

Some Laboratory Inspections

During the past week several interesting inspections have been held, giving those interested an annual opportunity of seeing well-known laboratories. The first was the Fuel Research Station at Greenwich. In a variety of laboratories estimations and analyses were being made on coal, and in the main building is located large-scale plant for coal carbonisation, gas manufacture and the firing of boilers with pulverised fuel. In a special building work on the hydrogenation of coal is in progress. The layout, equipment and staff are on a scale commensurate with the importance of fuel to this country, and the cost is wholly provided by the State. The annual inspection of the National Physical Laboratory took place the next day, and, as usual, succeeded in interesting and astonishing a large number of visitors.

Another important event was the opening inspection by Lord Rutherford of the central research laboratories of United Steel Companies, Limited, at Stocksbridge. This well-known combine unites about a dozen pig-iron, iron and steel and colliery undertakings, producing about one-sixth of the British output of pig-iron and steel. It is interesting to note that each producing unit has its own works research laboratory, and yet it has been found expedient to establish a central laboratory. The company also explicitly states that they are members of, and co-operate in the work of, all the appropriate Research Associations, as they do with the national laboratories. The whole building is not only an impressive tribute to the value of research to a modern industrial organisation, but is in itself a pleasing and well-equipped building, which many research workers will envy. Late as it was when British industry became science-conscious, the leeway is gradually being made up, and industry is becoming permeated with a network of laboratories staffed by trained men. To this the foundry industry is no exception, and it is a matter for congratulation that, in spite of its lack of central organisation, the industry has in the Cast Iron Research Association a national body to look after its interests. The proportion of small undertakings is probably greater in the foundry industry than in any other branch of the iron and steel industry.

It is under the direction of Dr. T. Swindon, D.Met., a Past-President of the Sheffield Branch of the Institute of British Foundrymen.

Satisfaction Clause in Contracts of Sale

So far as it proceeds on the Sale of Goods Act, the judgment of the House of Lords in *Cammell Laird & Company* v. *Manganese Bronze, etc., Company*, reversing the decision of the Court of Appeal contains comparatively little that is new. It follows the well-known precedent of *Manchester Liners* v. *Rea, Limited* (1922). The statute referred to provides (Sec. 14) that there is no implied warranty as to quality or fitness for any particular purpose of goods supplied under any contract of sale except that where the buyer expressly or by implication makes known to the seller the particular purpose for which the goods are required, so as to show that the buyer relies on the seller's skill or judgment and the goods are of a description which it is in the course of the seller's business to supply, whether he be the manufacturer or not; there is an implied condition that the goods shall be reasonably fit for such purpose. In *Manchester Liners* v. *Rea, Limited*, the matter in question concerned a contract for the sale of bunker coal for a named steamer. The coal tendered was unfit for use in that steamer which had natural-draft furnaces. It was held by the House of Lords that the coal was ordered for a particular purpose; it was expressed for the use of a particular steamship, and it must therefore be assumed that the suppliers knew the nature of her furnaces and the character of the coal she used.

Now in Cammell Laird's case that firm of shipbuilders, who were the appellants, had contracted to build two sister ships for United Molasses Company, Limited, each vessel to be constructed and to be classed at Lloyd's 100 A.1. On May 19 the appellants placed with the respondents, Manganese Bronze & Brass Company, Limited, an order for a "Parsons" manganese bronze propeller for each of the two vessels, the order providing *inter alia* that the propellers were "to be to the entire satisfaction of the owners' representatives and ourselves." The propellers were duly delivered and fitted to the two vessels, and one of them proved satisfactory on trial. At the trial of the other vessel a noise occurred when the engines were running at below 100 revs. per minute of so serious a character that the vessel could not be passed and classed at Lloyd's as A.1. The source of the noise was ascertained to be in the propeller, and a first replace was constructed, which, however, was also unsatisfactory. A second replace proved satisfactory. All four propellers provided by the respondents were constructed in all respects in accordance with the specification and a working plan; generally speaking, however, the weight of each of the two satisfactory propellers was slightly greater than that of either of the unsatisfactory ones. On the appellants suing the respondents for damages for alleged breach of contract, the judge of first instance decided in their favour,

but his judgment was reversed by a majority of the Court of Appeal. The House of Lords have now held that the appellants had brought themselves within the provisions of Sec. 14 above quoted, and the particular purpose for which the goods were required was made known by the appellants to the respondents so as to show that the appellants, as buyers, relied on the sellers' skill and judgment.

But the important feature of the case was that notwithstanding the goods in question had been constructed according to specification and plan, the court felt themselves bound to give some effect to the clause in the contract requiring them to be "*to the satisfaction of* the owners and ourselves." Such a clause is equivalent practically to giving the buyer or a third party a right of rejection which he possibly may require to do but little to justify. If the right is not absolute it seems nearly so. The clause itself is therefore one which a seller should not allow to appear in any contract of sale, unless he distinctly realises its import and how completely he may thereby place himself in the hands of the buyer, and is prepared to take such a risk. In the Court of Appeal several judges stated that if an article is manufactured according to specification and is of good material and workmanship, the buyer has no right, even under such a clause as that quoted, to express dissatisfaction about something else which is not in the contract and thereby add a term to the contract. Satisfaction must be limited to something which under the contract the manufacturer has bound himself to do. That construction, however, has not been upheld.

Correspondence

[*We accept no responsibility for the statements made or the opinions expressed by our correspondents.*]

Phosphorus and Porosity

To the Editor of THE FOUNDRY TRADE JOURNAL.

SIR,—We have read with considerable interest "A Report of the Work of the Cast Iron Sub-Committee of the Technical Committee" in your current issue, taking particular notice of phosphorus in relation to porosity.

Findings under "Conclusions from Porosity Tests" strike so much across experience and observations made by us over a number of years, that we venture to pose this question: Is it certain that results with varying percentages of phosphorus are entirely comparable when those variations are obtained by adding ferro-phosphorus, as when those same proportions are found as natural inherent quantities?

At the same time, mention is made of "low-carbon hematite," by which one might reasonably inquire whether this is passed through a converter, or other means of refining.—Yours, etc.,

For Frodair Iron & Steel Company, Limited,
G. F. JOHNSON,
Director.

Fenchurch House,
London, E.C.3.
June 29, 1934.

"Fettling" the Cupola

To the Editor of THE FOUNDRY TRADE JOURNAL.

SIR,—With reference to the letter signed "C. F." in the Readers' Queries Column of your issue dated June 14, we have had nearly 100 years' experience in foundry practice, and can confirm that it is necessary to "fettle" the cupola after each cast. We use a collapsible ladder for the purpose, and are pleased to say that, following research work in this particular branch, the job is now much simplified. We refer to the use of fused sodium-carbonate blocks to assist both the process of casting and to lengthen the life of the cupola lining.

The sodium carbonate has the effect of putting a much smoother surface on the cupola lining, so that the "fettling" is reduced by at least an hour a day, and the quantity of ganister used for mending is also greatly reduced.

We shall be pleased to give your correspondent any further details as to quantities, methods, etc., if he has had no experience of this modern acquisition to the foundry.—Yours, etc.,

HENRY BATES & SONS,
JOHN H. BATES.

Witton Foundry, Northwich.

The Institute of British Foundrymen

At a meeting of the General Council of the Institute of British Foundrymen, held at the Midland Hotel, Manchester, on June 5, the following were elected to the various grades of membership:—

As Members.

Hampton, F. E., foundry manager, J. Summers & Sons, Limited, Shotton, Chester; Harding, E. W., foundry manager, Robert Mitchell Company, St. Laurent, Quebec, Canada; Martin, R. A., B.A. (Cantab), technical representative, British Pigirons, Limited, London, S.W.1; Slater, I. G., M.Sc., Ph.D., metallurgist, British Non-Ferrous Metals Research Association, London, N.W.1; Stott, B. E., general manager, Ferrous Light Castings, Limited, Warrington; Zirker, G. H., D.Eng., managing director, Zirker & Sambidge, Limited, London, S.W.1; Harrison, S. G., foundry manager; Alcouwer, J. S., superintendent foundry and patternshop, Werkspoor, N.V., Amsterdam; Ayckbourn, P. J., B.Sc., engineer, Cambrian Engineering Company, Limited, New Plymouth; Hartley, W. H., director, Jos. Henry, Limited, Holbeck, Leeds; Williams, G., works manager, James & Company (Birmingham), Limited, Halesowen.

As Associate Members.

Jackson, A. E., foundry manager, Jackson Bros. (Milton), Limited, Stoke-on-Trent; **Picken**, E. W., assistant foundry manager, Sinclair Iron Company, Limited, Ketley, Wellington; Pittaway, F. J., foreman patternmaker, Robey & Company, Lincoln; Benfield, A., assistant manager, Lancashire Steel Corporation, Irlam; Harris, S. J., office manager, Park Foundry (Belper), Limited, Belper.

Catalogue Received

Refined Pig-Iron. The Stanton Ironworks Company, Limited, Stanton, near Nottingham, have prepared a very neat 12-page pamphlet dealing with Stanton-Dale refined pig-iron. The outstanding features are that it is made in seven grades, and a certificate of analysis is available for each consignment. The grading is based on the phosphorus content associated with silicon. Grades A, B and C carry 0.7 per cent. phosphorus, with the silicon decreasing from 2.0 to 1.0 per cent. Grade D has 0.5 per cent. P, with 2½ per cent. Si, whilst E, F and G are standardised at 0.25 per cent. P, with the silicons increasing from 1.0 to 2.0 per cent. Page 5 illustrates the fractures and unetched structure at 50 dias. Page 9 illustrates the Stanton laboratories, whilst 10 and 12 contain pictures of castings made from Stanton-Dale pig-iron by Wallwork, Platt Bros. and Morris Motors. Page 11 prints some useful data germane to cupola practice.

THE FIRST of the two new blast furnaces being erected by the Wellingborough Iron Company, Limited, is nearing completion and will be ready for work during the summer.

Random Shots

READER'S QUERY.

Mr. Blank, of Blanktown, operates a small non-ferrous jobbing foundry. His two bankruptcies, one of 1920 vintage, the other of quite recent date, indicate with what measure of success he has pursued his career in the foundry industry. They do not indicate, though, with what success his creditors pursued *him*. Sufficient to say that, as a practical foundryman, Mr. Blank knows his stuff. Why, he was telling "Marksman" only last week that he no longer has to go to the trouble of "arranging" his test-bars—he has taught a first-year apprentice to do the job.

* * *

"My trouble is not casting but costing," writes Mr. Blank. "If you remember, years ago I wrote asking you what was the simplest method of costing you could recommend, and you gave me the formula: x (R.M. + L. + O.H. + P. + y) ÷ 280 or thereabouts. This worked very successfully for some weeks, when financial disaster suddenly overtook me. When I re-entered the industry after a space of ten years or so, I found that I had mislaid your formula; nevertheless, I managed to rub along fairly comfortably until such time as I was able to reclaim my waistcoat, in a pocket of which the formula had been placed. Would you please be so kind as once again to explain how to apply the formula in modern foundry costing?"

* * *

"Markman's" Costing Expert, in a reply to the above query, writes: "I am delighted to come to the assistance once more of a correspondent of so many years standing. Referring to the formula, R.M. is the cost of all raw materials per annum; L. is the annual cost of labour (both direct and indirect); O.H. represents overheads; P. is the (hypothetical, tax-free) profit; and y, a little something the others haven't got. The expression "280 or thereabouts," indicates the number of working days per annum, and x the number of days the job will take, estimated usually on a time basis. If you wish to study the matter in greater detail, I will send you formulæ which take into account the factor of floor space."

MARKSMAN.

Notes Around the Branches

LOCAL FOUNDRYMEN VISIT BILLINGHAM WORKS

Thanks to the courtesy of the officials of the Imperial Chemical Industries, Limited, of Billingham, the Middlesbrough Branch of the Institute of British Foundrymen organised a visit of its members to these works on Wednesday.

Before proceeding round the works, a few lantern slides were shown in order to explain the general lay-out and the fundamentals of the process for manufacturing nitrogen and ammonia synthetically.

It was explained that these products served the two opposite purposes of maintaining plant life (as fertilisers) and destroying human life by means of explosives. Fortunately, at present the output was for the former purpose.

Members were shown the plant for manufacturing water-gas and producer-gas, and the special boilers fired by pulverised coal. After this they were shown how this gas was compressed to about 3,750 lbs. per sq. in., and after purification the nitrogen and hydrogen were combined by means of a catalyser, at high pressure and temperature, into ammonia-gas. This ammonia-gas was then converted into ammonium sulphate and other nitrogen products.

The visit was well attended and thoroughly appreciated by the members. A vote of thanks was given to the officials and staff by the BRANCH-PRESIDENT, Mr. J. Hackwood, supported by MR. H. E. WOOLLEY.

On the Use of High-Duty Cast Iron in the Manufacture of Textile Machinery*

By A. Roeder (Chief Chemist, Société Alsacienne de Construction Mécaniques, Mulhouse)

[French Exchange Paper.]

Mechanical engineers have been led of late to pay greater attention than in pre-war years to the researches carried out by metallurgists in the realm of cast iron. The application of these researches soon had the effect of bringing about notable improvements in the mechanical and physical properties of the material. The influence of two important factors have been ascertained, namely, the constitution of the metal and its structure. When due weight is attached to these factors, the cast iron obtained is of superior quality, eutectoid or pearlitic, distinguished from other brands of cast iron in that it has a quasi-isotropic structure, a feature that may be considered as the one which confers to machine parts their high mechanical resistance to external stresses. Various methods of manufacture have been perfected, and are now in current use in France and in other countries. Space does not allow of reviewing in the present instance the various processes followed; moreover, foundrymen are well acquainted with them.

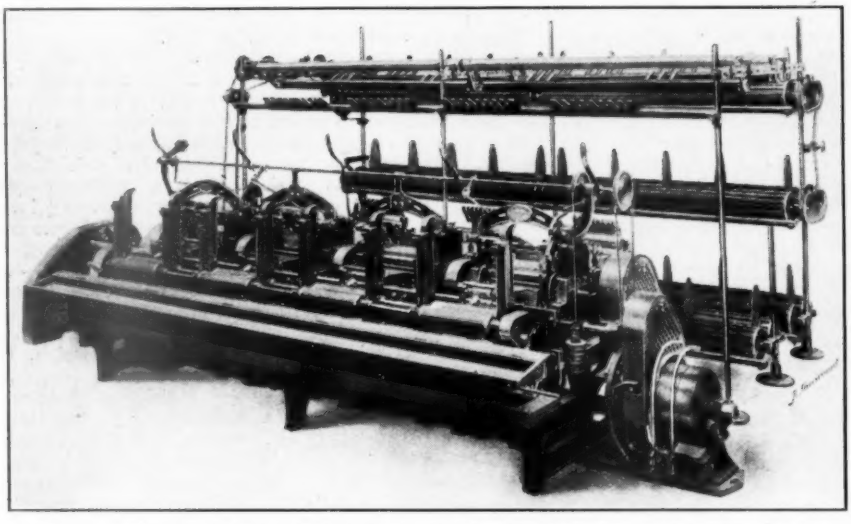


Fig. 1.—Modern Textile Machine which Utilises High-Duty Iron for Its Components.

High-grade cast iron was used in the first place in the manufacture of heavy machine parts, such as gas-engine and steam-engine cylinders, piston rings, and so forth. It was, however, soon found advisable to give to other branches of the engineering trade the benefit to be derived from the use of this same material. The International Foundry Exhibition held in Paris, in 1927, contained a number of spinning and weaving machine parts, namely, worm gears, intersecting and self-acting spool mechanisms, levers, calender and fluted roller gears, brake pulleys, etc., of high-duty cast iron. Fig. 1 illustrates a textile machine embodying such elements.

For a long time past two brands of cast iron were resorted to in the manufacture of the very many spinning and weaving machine parts as are illustrated in Fig. 2, these brands being:—(1) Cast iron of good quality; and (2) cast iron of an improved quality, to which there has been added high-duty iron as a third brand.

Two considerations govern the use of this third brand. In the first place, its mechanical properties are much above those of the other cast irons. Further, it enables engineers to deal with the problem of reducing the weight of moving parts, a great advantage in view of the increasing speeds and stresses to which machine elements are now subjected.

The superior quality of the metal ensures a higher resistance to tensile and bending stresses, to shearing and impact stresses; it also confers to the pieces a considerably higher fatigue limit. It should be noted in this connection that some component parts of textile machinery have to undergo in service endurance stresses having varying rates of high frequency, stresses the direction of which is constantly alternating between extensive positive and negative values.

Hence, the builders of textile machines have taken great interest in the very high increase in fatigue limit here referred to, and are using machine parts made of high-duty cast iron.

A second consideration is the no less important property of high-duty cast iron to yield castings which are highly resistant to wear. Although the problem of resistance to wear still remains a somewhat involved one, yet it may be stated that the structure of high-duty cast iron forms a comparatively safe criterion to go by.

A maximum resistance to wear may be said to be ensured by the presence in the metal of graphite in long and thin laminæ, and of a lamellar pearlitic matrix. A similar structure is met with particularly in the pearlitic cast irons of the Lanz system.

The object of the present Paper is to point out the resistance values of the high-duty cast irons in question, by showing the results obtained in the course of tests on specimens which were not cast separately but were taken from the castings themselves. For comparison, the results are given of similar tests on similar castings (see Fig. 3), but made of the other brands. The brands tested are marked A, B and C, and have the following significance:—A to cast iron of good quality; B to cast iron of improved quality; C to high-duty cast iron.

Mechanical Tests

I.—*Shearing tests*, with the Frémont-S.A.C.M. machine, on test specimens 5.64 mm. (0.220 in.) in diameter, taken from the casting shown in Fig. 3.

A cast iron :

R_c	=	24	24	24.9	25.5
Average	=	24.6 k. per sq. mm.			
	=	15.62 tons per sq. in.			

B cast iron :

R_c	=	30.4	29.9	30.9	30.3
Average	=	30.4 k. per sq. mm.			
	=	19.30 tons per sq. in.			

C cast iron :

R_c	=	37.1	43.7	40.9	43.1	38.9
Average	=	40.9 k. per sq. mm.				
	=	25.97 tons per sq. in.				

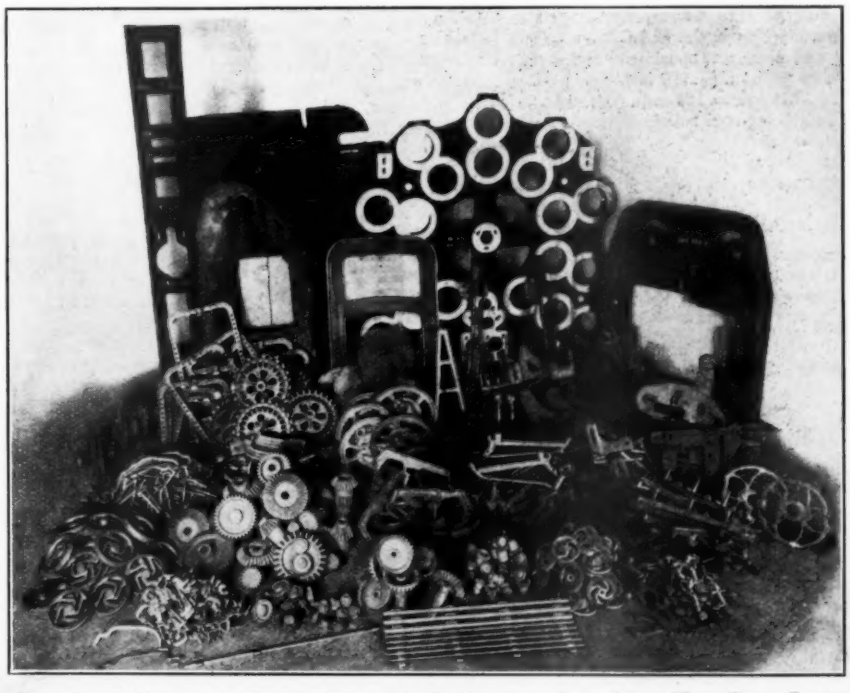


Fig. 2.—A Group of Textile Engineering Castings made from High-Duty Iron.

* A Paper read before the Annual Conference of the Institute of British Foundrymen held at Manchester, June 5 to June 8.

II.—*Transverse tests*, with the combined Frémont-S.A.C.M. machine, on standard test specimens 35 × 10 × 8 mm. (1.378 × 0.393 × 0.315 in.); distance between supports 30 mm. (1.181 in.).

A cast iron :
Total breaking load = 665 695
Average = 680 k. = 1,500 lbs.
Deflection previous to rupture = 0.18 0.20
Average = 0.19 mm. = 0.0074 in.

B cast iron :
Total breaking load = 915 953
Average = 934 k. = 2,060 lbs.
Deflection previous to rupture = 0.20 0.22
Average = 0.21 mm. = 0.0078 in.

C cast iron :
Total breaking load = 1,264 1,320
Average = 1,292 k. = 2,850 lbs.
Deflection previous to rupture = 0.22 0.24
Average = 0.23 mm. = 0.0089 in.

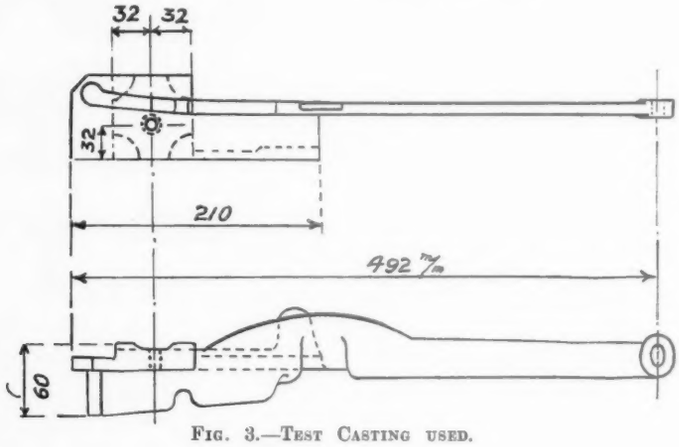


FIG. 3.—TEST CASTING USED.

III.—*Repeated impact tests*, with the S.A.C.M. machine, on test specimens 10 mm. (0.393 in.) in diameter, unnotched.

A cast iron :
Number of blows causing rupture = 15 25

B cast iron :
Number of blows causing rupture = 180 240

C cast iron :
Number of blows causing rupture = 1.200 1,500

IV.—*Fatigue tests under alternate stresses* (rotary bending) with the S.A.C.M. machine (Woehler system), on test specimens turned to a diameter of 10.65 mm. (0.419 in.).
Total length = 157 mm. (6.180 in.).
Length between reference marks = 140 mm. (5.512 in.)

A cast iron :
Alternate stress : $\sigma = \pm 14.8$ k. per sq. mm. = 9.40 tons per sq. in.
Alternations : $n = 61{,}983$ (up to rupture).

B cast iron :
Alternate stress : $\sigma = \pm 14.8$ k. per sq. mm.
Alternations : $n = 404{,}380$ (up to rupture).

C cast iron :
Alternate stress : $\sigma = \pm 14.8$ k. per sq. mm.
Alternations : $n = 10{,}000{,}000$ (not ruptured).

The above results clearly show the superiority of the C cast iron over the two other brands A and B, which, formerly, were the only ones used in the making of castings for spinning and weaving machines. The high-duty brand of cast iron has greatly contributed to the progress achieved in the construction of textile machinery.

DISCUSSION

High-Duty Iron Deemed Unnecessary

MR. E. LONGDEN said an impression might be conveyed that British textile-engineering founders were not competent, but he did not think that was so. It was true that the constitution and structure (which might mean the same thing) of cast iron had had much closer attention during the past ten years than formerly, and that if due regard was paid to the physical make-up as well as to the chemical composition, metals of improved strength could be produced, as the author had stated, by increasing the pearlitic area (as the result of special processes) beyond that obtained by ordinary casting methods. It was also true that such material possessed greater mechanical resistance to external stresses.

For many decades British textile-machinery makers had produced very high-class machines from castings made of high-grade material. The sections of castings had been cut down to very fine limits. Again, he had still to learn that there was any need for the reduction of sections, since actual replacements were not frequent; nor were there so many moving parts as to warrant re-designing machines and parts, because when once such members were set in motion they required very little power to continue their movement. There was probably more strain set up by incorrect setting of parts or mal-alignment and faulty machining than by the carrying of a comparatively small additional weight of metal.

However, he suggested that it was not practicable to use high-duty iron in more than 5 per cent. of the textile-machine castings—and he assumed that "high-duty" iron was intended to mean metal whose constituents and structure were controlled within very fine limits. Such metal must be made by such processes as the Lanz hot-mould method, or processes used for the production of Emmel iron, Meehanite, nickel iron, and low-carbon iron (the latter produced by rotary furnaces). With the exception of Emmel iron and the low-total-carbon iron, these metals were essentially of low-total-silicon content and might contain very little phosphorus; and the low-total-carbon iron, whether produced by the rotary furnace or by the Emmel process, could be brought within the same category as being metals which could not be cast with the degree of ease necessary in the production of textile-machinery castings.

For the 5 per cent. of textile-machine castings which might be made by special processes, probably steel castings would be less expensive. Mr. Longden ventured to suggest that costs of production would increase very considerably if high-duty castings were substituted for the high-grade cast iron now used in textile machines. The reasons he gave were the higher initial cost of high-duty iron; the increase in the general manufacturing cost of the castings due to extra moulding operations, and greater hazards due to the comparative viscosities or fluidity of the metal, which would create a greater percentage of waster castings; and that machining speeds would be seriously reduced due to the greater density and hardness of the cast iron.

From 6 to 8 per cent. of textile-machinery castings were annealed at a temperature of approximately 850 to 900 deg. C. for from 6 to 8 hrs. in order to create dead-soft machining properties, and most remarkable machining speeds were attained with the annealed metal. Such dead-soft metal could not be obtained even with nickel. It might be suggested that the high-duty iron could be annealed, and he agreed that it could, but he also pointed out that annealing seriously reduced the strength of cast iron, so that the purpose of introducing the high-duty iron would be defeated. Again, it would entail further expense.

In a British textile machine similar to that shown in Fig. 1 there were not many parts warranting the use of high-duty iron. The underframes were required to have sufficient rigidity and body to absorb or prevent vibration, but at the same time their thickness did not average more than from $\frac{3}{8}$ in. to $\frac{5}{8}$ in. The thickness of stretchers and beams were from about $\frac{1}{4}$ in. to $\frac{7}{16}$ in. The thickness in the thin areas of some of the fluted rollers shown in the foreground of Fig. 1 was not more than $\frac{1}{8}$ in. when machined, and the general section of many more parts was not much more than $\frac{1}{4}$ in. The thickness of the bodies of various types of cast-iron spindles, when machined, varied from $\frac{1}{8}$ in. to $\frac{1}{4}$ in.

On the other hand, there were rollers of from $\frac{1}{2}$ in. to 5 in. dia. and up to 9 in. long, highly polished, which were required to possess weight and body. The main cylinders of a carding engine might have a diameter of 42 in., and 42-in. face, giving a surface area of 5,540 sq. in. The black castings were $\frac{3}{8}$-in. section, except where strengthened by shallow bands, and machined down to $\frac{1}{4}$ in. thickness. Such castings were difficult to produce in any other iron than that which had already proved successful, and the use of modern high-duty iron would be very risky and expensive. There was another casting, named a "flat," which stretched across the face of the cylinders (there were usually about 100 on each machine) and acted like a comb; this casting was of T section, and the general thickness was $\frac{1}{4}$ in. These castings were the most sensitive of any that a foundryman could have to make, and quickly responded to chilling by a departure from the metal mixture, or in the moulding, such as by the use of damp sand, or flash or fin, however slight, forming on the joint of the mould which created white iron, such chill pentrating into the section of the casting preventing group machining.

The whole range of textile-machinery castings could be included in the following four ranges of analysis :—

T.C.	Si.	Mn.	P.	S.
Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
3.35	2.75	0.7	0.6	0.08
3.3	2.50	0.7	0.8	0.09
3.3	2.25	0.7	0.9	0.09
3.3	1.50	0.7	0.9	0.09

He maintained that British textile engineers had been using the very best metal possible; their metals were considered to be of good quality and very suitable for the duties they had to perform. The complaint is that British textile machinery lasts too long and does not induce the purchase of the more recent type of machines.

MR. SUTCLIFFE mentioned that one British firm was using 25 per cent. pig-iron and 75 per cent. scrap for textile-machinery castings.

MR. J. H. COOPER said that the author—who was obviously a clever man, judging by his status in France—should be given credit for having tried to put them on a line which might result in improvement. Although they might not be using high-duty iron in this country, they had seen textile machinery made with a good deal of scrap which was not always up to the 100 per cent. efficiency mark. Doubtless the author had quite good answers to the points made in the discussion; it could be accepted that he would not have prepared the Paper unless he had had good reason for putting forward his arguments.

Non-Ferrous Foundry Practice

DISCUSSION AT MANCHESTER CONFERENCE

(*Continued from page* 415, *Vol.* 50.)

Limiting Initiative

MR. W. DUNKERLEY, speaking in reference to standardisation, asked was it to be assumed that if there were six alloys for the whole range that all necessary research with regard to alloys had been completed? He was a chemist, and, on occasion, was given problems in the foundry which necessitated a certain amount of local research work being done. It might be found necessary to add nickel, or other metal, to an alloy. If it were to be assumed that all that was necessary was to go to the six alloys which had been recommended by the various speakers, it would militate against individual effort in any particular works in connection with alloys.

MR. PRIMROSE said that in alloys for which the Sub-Committee had drawn up tentative specifications for passing in time for the B.S.I., they had been very careful to give, as far as possible, ranges of the metal added to the alloys, which, in some cases, with the higher lead contents, included as much as 2 per cent. of nickel. Even the No. 2 or No. 3 alloy would have quite a range in which to achieve individual effort, and it was hoped to give the limit of a minimum tensile and other values that would be attainable by ordinary methods of casting. While standardisation was the keynote it was not what might be termed a "cast iron" standardisation that must be "dead on" to the exact composition. There would be a range of variation of two or three added metals.

It would be noticed that the alloys cast and mentioned in the Paper had all been made in an induction electric furnace. This was an ideal method which eliminated a great many of the practical difficulties Mr. Harley had mentioned, and it was slightly academic, possibly ruling out some effects such as that of sulphur due to oil-fired or pit-fired furnaces.

MR. A. LOGAN, also referring to the question of standardisation, thought that Mr. Harley's remarks touched the crux of the whole point. It had been stated that the motor industry could do the whole of their bronze work by means of six copper alloys. He (the speaker), as a metallurgist, would say that the marine engineering industry could do their work also with the same number, at any rate it could be done in the case of his own works where they had only their own internal castings to consider. Nevertheless, when dealing with outside work, they were forced to make a tremendous number of alloys which they knew were of no practical significance or importance at all, and particularly so with regard to locomotive work.

MR. J. E. O. LITTLE, speaking from the locomotive point of view, stated that the L.N.E.R. Company had just issued instructions to all their brass foundries to use six standard alloys. Apparently standardisation would have to be national, as standardisation by individuals would lead to greater chaos than before. The spiral test for fluidity was an interesting point. He had been trying to compare accurately the furnaces in four different brass foundries belonging to his Company. These furnaces differed from one another. He included the spiral test, but he found that if he went from one foundry to another with the same pattern he could not get the same casting. The moulders did not make them the same thickness or with the same finish.

Interlinking Requirements

MR. C. E. WILLIAMS (Past-President) noticed that Mr. Harley did not say that six alloys would be sufficient for all industries. Was it possible for the Institute of British Foundrymen to become a useful link for joining up the locomotive, the electrical, the shipbuilding, and other industries, and if they were all going on sixes to see how far those sixes might be interlinked?

MR. A. LOGAN said that each different industry usually used a bronze or bronzes of the gunmetal type and they might also use a leaded bronze. Those two types were the types standardised, or attempted to be standardised. There was a range of six straight gunmetals and a range of six leaded phosphor bronzes; and when these alloys were put through would be applicable to any industry. There was no question of an industry requiring six different types for their own industry; the six different standards would be available or suitable for any industry. There would be no over-lapping.

MR. S. G. HARRISON inquired whether, if standardisation was not to be of the "cast iron" category, he would not be right in saying that before very long there would be a lot of rather mixed scrap again, thus defeating the object of standardisation.

MR. J. S. G. PRIMROSE said that an attempt had been made to establish a sufficient difference between the various standard alloys so that variations would still remain within the classification. A No. 3 alloy scrap, within its variations, could still be used as No. 3 alloy; it would not drop into No. 2 or No. 1. While a range was being established there would be a sufficient distinction between it and another range.

MR. V. DELPORT, speaking on behalf of the author of the Paper, said that he would have very great pleasure in conveying to the American Foundrymen's Association the very kind expressions of opinion which had been stated with regard to the Paper. Personally, he had been particularly delighted at the interest shown in it by the discussion. Perhaps the Paper could not be referred to as being of a scientific character, but it was certainly a highly technical one, whilst at the same time it presented wide practical aspects and results in the simplification of the work of the foundry, and especially so when coupled with the investigations of the British Non-Ferrous Sub-Committee.

THE CHAIRMAN, in closing the discussion, said he could quite sympathise with the attitude of mind of both Mr. Faulkner and Mr. Dunkerley, having regard to what had happened to standardisation in the past. Specifications had been standardised in the past, and as years went on variations crept in, and there was a tendency for a chaotic state to supervene once more. It had happened, in certain directions, with regard to cast iron.

After the author (Mr. Francis W. Rowe) had introduced his Paper, MR. V. C. FAULKNER inquired whether the author of the Paper could give any reference which would confirm his figure that the Brinell hardness of the alpha-delta eutectoid in cast bronze was of the order of 400. Personally, he had been unable to confirm that figure, and from inquiries made in the London area the usual figures appeared to be of a much lower order. Had Mr. Rowe made any "life" tests which were now erroneously being called fluidity tests, in so much as it had been tacitly admitted by one speaker that "life" was the same as fluidity, in his correlation with temperature. The object of the spiral test was to differentiate between the fluidity and "life." "Life" was the ability of the liquid metal to fill a mould. Apparently, one member present found such a test useless. He would like to suggest that if that member desired to ascertain the best dressing for a mould there could be no better way to do so than by means of the spiral "life" test. He could then ascertain which of the mould dressings influenced the property of life or ability to fill a mould with the metal. That was the kind of work for which foundrymen were looking.

Hardness of Alpha-Delta Bronze

MR. ROWE stated that the Brinell hardness figures cited were entirely his own, with regard to the hardness of the alpha-delta eutectoid such as was present in more or less amount in all gunmetals and bronzes containing above 6 or 7 per cent. of tin, and he did not know any reference which could be mentioned with respect to them, though he had searched in past years for some actual hardness determinations on such various constituents as appeared in a bronze. In the foundries and laboratories of the firm with which he was associated a considerable amount of time and money had been devoted to obtaining some reasonably accurate determinations of the hardnesses of the various constituents in bronzes. Quite sufficient work had been done, and figures computed, to form the subject of a separate Paper.

An Outstanding Feature

The figures were rather startling. It would be appreciated that it was the hardness of the constituents in the bronze which formed the whole explanation as to why the tin-bronzes and the gunmetals were of such great value in the engineering industry, and also why so many of the so-called cheaper alloys which were put forward to replace bronzes were more or less bound to fail.

The type of bronze referred to in the Paper would never be replaced unless metallographic features, or features of differential hardness, and similar type of structure could be duplicated. The value of a bronze and of a gunmetal in industry did not depend on its ordinary physical characteristics, such as tensile strength and hardness. Those could be quite easily duplicated by other alloys. The value of a bronze depended almost entirely on the fact that it had the same sort of structure as a macadam road; namely, that there were particles of granite-like hardness immersed in a relatively soft and plastic structure, and it could not be replaced by material all of the same hardness.

Utility of the Spiral Test

So far he had not done any work on the fluidity test as regards bronze, but he did appreciate the point of Mr. Faulkner's remarks that when testing the value of various mould materials "life" tests, such as were being discussed and propounded, would be of great value. With regard to the comparison of various bronzes by means of their "life" tests, he was bound to sympathise with Mr. Logan in that, so far, other points had proved of much greater value and the determination of other properties was needed much more than the so-called fluidity tests.

THE CHAIRMAN (Mr. J. E. Hurst) thought it would have been preferable if Mr. Rowe had stated that the value of bronze was due to the fact it had a structure more like cast iron.

Density Curves and Impact Values

DR. J. W. DONALDSON, in thanking Mr. Rowe for his very interesting and practical Paper, said that the value of the Paper would have been increased, if a maximum point had been obtained in the density curves of the alloys in Series III to VI by the lowering of the casting temperature.

With regard to the impact values given in Table I, these had been obtained on a 20-mm. square bar. He would be glad to know how these values compared with values obtained on a 10-mm. square bar or a 0.45-in. round bar. Such values would certainly be lower, but would be of greater value for comparison with values obtained for steels.

XUM

Reasons for the Ranges Chosen

MR. ROWE said that an attempt had been made to compare the physical properties of the alloys when cast over the same range of casting temperature. Had time and facilities permitted, the range might have been extended for the lower melting-point alloys, whereas five casting temperatures for the higher melting-point alloys had been used.

Regarding the impact tests shown in Table I, it was not possible at the moment to give the information with respect to comparative values obtained on the standard 10-mm. square bar. The 20-mm. square bar had been adopted many years ago, because it was found that, in the case of the relatively brittle alloys, the differentiation which was obtained with a standard 10-mm. square bar was not sufficiently high. The larger bar was also adopted for cast iron in order to give a greater amount of differentiation among the relatively brittle alloys, such as the brittle bronzes and the cast irons.

Divergent Results

MR. A. HARLEY also raised a point in regard to Table I. Looking at Series 2 and Series 5, it would be found in the case of the two alloys mentioned, the only difference was that one was 1 per cent. of phosphorus. The casting temperature was a little lower than for phosphor bronze, and there were extraordinary variations in the results. In the case of the phosphor bronze, the yield-point gained about a ton. The ultimate stress lost about 3 tons, while the impact value of phosphor bronze was only 50 per cent. of the ordinary tin bronze. The Brinell hardness was practically identical, and the density of the phosphor bronze was definitely less than the ordinary tin bronze. Could Mr. Rowe throw any light upon why the difference in composition should produce such values?

Influence of Phosphorus

MR. ROWE said that Mr. Harley had raised the very relevant question of the difference in physical properties shown in Table I between Series 2 Alloy, which was a straight tin bronze of 10.5 per cent. tin, and a similar alloy with the addition of 1 per cent. phosphorus in Series 5. As a hardener, tin was preferable to phosphorus. An ordinary bronze could be hardened by either increasing the tin content or increasing the phosphorus content. Generally speaking, the main difference between two alloys of relatively similar hardness, or one which contained no phosphorus and one which contained a fairly large proportion of phosphorus, was that the higher phosphorus alloy was more brittle. There was no corresponding advantage beyond cheapness in hardening with phosphorus, while there was a definite loss as regards shock strength and liability to fracture under similar conditions to those obtaining in the impact test-bar.

The results were, of course, not strictly comparable, because the tin content in Series 2 was 0.5 per cent. higher than in Series 5, and there was, of course, the variation in casting temperature.

He would not like to say that this difference of 80 deg. in casting temperature was sufficient to make the two alloys relatively similar. It was known, of course, that with a 1 per cent. phosphorus the casting temperature should be lowered because the freezing point was depressed, but he would not say the two series were strictly comparable. They indicated the general trend which was obtained as regards phosphorus, that the alloys did become more brittle when hardening with phosphorus than when hardening with tin.

With regard to the density tests, 1 per cent. of phosphorus, even on theoretical calculations, made a considerable difference to the density. The results as regards density were more or less comparable with hundreds of other similar classes of alloys, namely, that alloys with high phosphorus content had definitely a lower density, even under the best conditions, than the tin bronzes without phosphorus.

MR. HARLEY inquired how the density test was carried out?

MR. ROWE replied that the bottom half of the middle portion of each of the test-bars was taken in total, the cross-section of the test-bars was taken half-way from top to bottom, and a determination made by the usual weighing in air and weighing in water for specific gravity.

True Equilibrium Diagram

MR. J. S. G. PRIMROSE said he could not recognise the equilibrium diagram in Fig. 1. He would like to ask for the authority for the latest ones. He knew the diagram by Shepherd, given in 1896, and he knew the one produced in the Institute of Metals Paper by Prof. Hoyt in 1913, who definitely brought in the gamma and ignored the beta. Mr. Rowe showed that the delta came in somewhere in the region of 10 per cent. and put it as actually beyond 15 per cent. according to the diagram.

Early in the Paper it was stated that to obtain equilibrium with 15 per cent. tin alloys they needed several weeks of careful annealing. He did not think any of them would contemplate the annealing of phosphor bronzes for a few weeks, and he believed it would spoil all Mr. Rowe's alloys as bearings if he did so.

They had been shown what no doubt Mr. Rowe would describe as a true equilibrium diagram, but what was wanted was a working diagram which brought in the gamma range in cooling and in which the delta came in much nearer 10 per cent. as in actual practice.

Foundry Use of Equilibrium Diagrams

MR. ROWE said that the equilibrium diagram had been compiled by himself from all the existing data on the copper-tin series. He had endeavoured to embody, as far as was possible, a reasonable compromise between conflicting views. He had at other times, and in other places, given some idea as to how the normal foundry alloys differed from the equilibrium diagram, and a fair indication had been given to foundrymen as to how much alpha-delta eutectoid was to be expected in sand-castings of various compositions, and the differences which could be expected in foundry practice as regards metallographic structure as contrasted with the true equilibrium diagram of alloys in a stable condition.

Density of Bronzes

MR. A. LOGAN pointed out that the only physical property results reported in the Paper were densities, which to the foundryman were, of course, of vital importance. The question of the maximum possible density of any alloy was of very practical importance in non-ferrous work, and from that point of view the Paper had struck a new note. It gave a number of alloys to refer to where the densities under various conditions were very clearly stated. Fig. 3 was a diagram of a mould containing four bars, but he assumed that it was not drawn to scale. The dimensions of the bars were given, but the space in between the bars was obviously too small. What would have amplified the Paper very much, and added to its interest, would have been complete macro etchings of the bars as cast, showing also the sink of the heads. He assumed that the density quoted was the average density of the whole bar. Had Mr. Rowe ascertained the densities of the outside and centres of the bars, and, if so, were the figures available?

Phosphorus and Porosity

The outstanding points of the Paper led to two very definite conclusions. By adding phosphorus to a bronze there was an undoubted increase in the chances of unsoundness and porosity. The other important feature, which was equally obvious, was that the fact of mass variation was not of such importance as casting temperature. Both the Papers read that morning led to the same conclusion. The systematic checking of casting temperatures was greatly neglected, and until it was realised by non-ferrous foundrymen to be necessary the value of the various research Papers read from time to time would be largely neutralised.

He would not like to be understood to state that the "life" test or fluidity test was of no value at all, but that as a practical control test it was of little use in a non-ferrous foundry.

Average Density Determinations

MR. ROWE replied that macro-etchings were prepared from the whole of the bars, but that it was not thought necessary to go to the cost of reproducing them.

The density tests were only taken as a whole cross-section of the bar, and, therefore, were average density tests. Complete Brinell hardness determinations were taken over the whole area of the bars, but owing to the sort of ideal way in which they were cast, with the whole of the bar being utilised as a runner and a riser, there was very little difference between the centre and the outside in all of the bars. Therefore, the Brinell figures were not published, because with them being more or less even throughout they did not add greatly to any knowledge which was likely to be imparted by the Paper.

Foundry difficulties were undoubtedly increased when an alloy contained a large amount of phosphorus, and there was a greater probability of unsound castings resulting therefrom together with low density.

Mass Variations

He accepted Mr. Logan's remarks with respect to mass variation with diffidence, because he did not consider the results stated in the Paper, in so far as they affected the question of mass on the physical properties, were figures which could be rigidly interpreted and quoted. He thought there was, of course, less variation due to mass than might have been expected, but he did not think the conditions would obtain in ordinary foundry practice, due to the fact that the bars had been cast under more or less ideal conditions. Taking, say, a ring casting, the average cross-section of which was similar to that of the ordinary small size bar, and run by the ordinary foundry methods, and a ring casting of similar cross-section as the largest size, there would probably be a greater variation due to mass effect.

The diagrammatic sketch (Fig. 2) did not show the full amount of space between the bars.

Inter-Crystalline Cracks

MR. W. DUNKERLEY mentioned the case of a bronze valve which leaked, and which, upon microscopic examination, exhibited a considerable number of inter-crystalline cracks which penetrated even into the eutectoid part as well. A perusal of Primrose's book on "Gun-metals" led him to assume that if the casting had been at a lower temperature the cracks would have been eliminated. Was it possible, by casting at a lower temperature, to get a denser material, and therefore one less likely to show inter-crystalline cracks?

MR. ROWE replied that temperature, *per se*, had no effect on density; what mattered was the rate of solidification of the alloy. If the rate of solidification was made sufficiently rapid as in the case of the chilled bar shown in the red brass Paper there was very little difference caused by the variation of casting temperature. Actually, variation in casting temperature in a sand mould caused greater alteration. The more rapid the rate of solidification the more dense was the alloy.

The inter-crystalline fissures noticed by Mr. Dunkerley were not due to high casting temperature, but were probably due to gas content in the bronze, which generally revealed itself more markedly with a low rate of solidification. It was not certain that the trouble would be

(*Concluded on page* 18.)

Contribution to the Study of Graphite Formation and Structure in Cast Iron and its Influence upon the Properties of the Cast Metal*

By Heinrich Nipper, Dr. Ing.

(Communication from the Giesserei-Institut of the Aachen Technical High School)

[GERMAN EXCHANGE PAPER]

DR.-ING. HEINRICH NIPPER.

The crystallisation of a melt is determined, according to the work carried out by Tammann,[1] by the factors "nuclei number, KZ," and "the velocity of crystallisation, KG." The mode of undercooling of a melt depends upon the values of KZ and KG, and their proportion to each other. Above all, undercooling is dependent upon the value of the preceding melting temperature, the duration of this, the presence of solid, liquid or gaseous constituents liable to cause inoculation, the rate at which cooling takes place, potential inoculation due to the furnace or container walls, the jolting of the melt, and so forth.

With reference to the influence which these factors have upon the rate of freezing of grey cast-iron melts of varying composition, the following general remarks may be put forward:—

The first effect of high superheating is to decrease viscosity. Impurities in the melts, consisting of coarse or of more or less dispersed oxides, silicates, etc., coagulate and are separated out. Even in the case of hypereutectic melts, all particles of graphite are entirely dissolved. The high degree of purity thus arrived at allows of an extensive undercooling of the melt. It has not so far been possible to ascertain experimentally to what extent molecular changes in the melt, due to the high superheating, may favour or may cause the marked tendency for undercooling. In this connection, the very complete researches by Piwowarsky,[2] by v. Keil, Mitsche, Legat and Trenkler,[3] and A. Reinhardt,[4] may be referred to.

Low Temperatures

Heating over a long period at comparatively lower temperatures has also, in the first place, a purifying effect, making for a coalescence of impurities and, apparently, for the critical particle size favourable to nuclear formation. The capacity for undercooling thus increases. The explanation given by Hanemann,[5] where he refers to the break-up of the graphite nucleus, is very improbable for normal working temperatures, according to the later researches by Piwowarsky.[6] Piwowarsky has been able to show that in soaking tests a few seconds are fully sufficient to break-up even coarse graphite flakes at melting temperature.

* A Paper read before the Annual Conference of the Institute of British Foundrymen held at Manchester on June 5 to June 8.

FIG. 1.—SHOWS HOW THE CRUCIBLE WALLS INFLUENCE GRAPHITE SIZE. × 100.

FIG. 3. × 100.

FIG. 4. × 100.

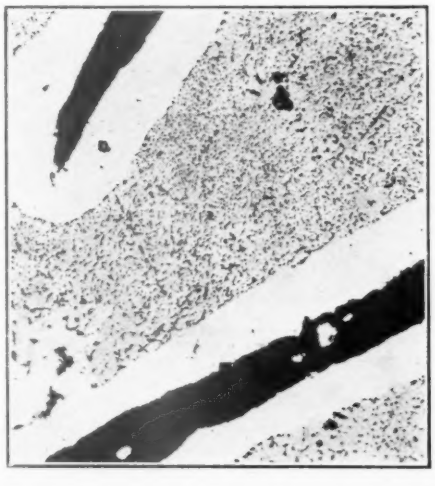


FIG. 2. — TWO GRAPHITE FLAKES (KISH) $\frac{5}{16}$ IN. LONG, WITH FINE EUTECTIC GRAPHITE. × 100.

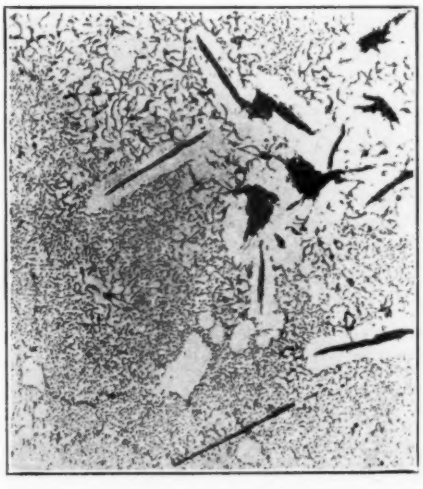


FIG. 5. × 100.

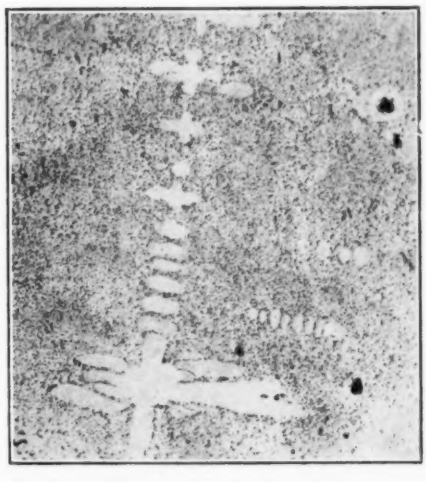


FIG. 6. × 100.

FIGS. 3 TO 6 SHOW WELL-DEFINED DENDRITES OF PRIMARY CRYSTALS IN HYPER-EUTECTIC MELTS.

Solid and liquid impurities present in an iron melt, according to their kind and the size of the particles, can largely lower the undercooling capacity on freezing. It is sufficient at this point to refer to new researches in this connection, namely, those of Reinhardt and v. Keil above mentioned. The after-siliconising effect and its gradual fading away by long standing may also come into play. (In regard to this, the researches by E. Piwowarsky[7] should be referred to.) A treatment of the melt with a suitable slag or direct refining have for effect largely to increase the undercooling capacity.

Gases in particular, when present in large quantities, and given out by the liquid melt and also in the freezing range, can greatly hinder undercooling. (With reference to this, the work

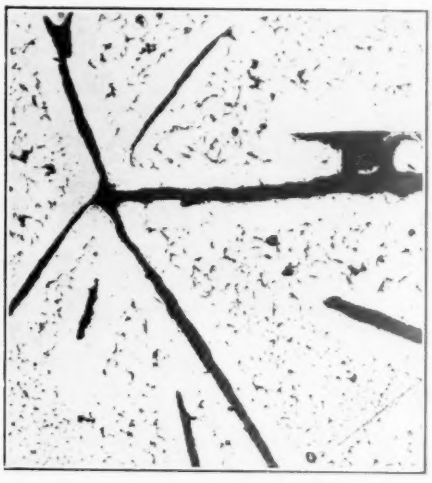


FIG. 7.—SHOWS COARSE GRAPHITE RADIATING FROM A NUCLEUS. × 100.

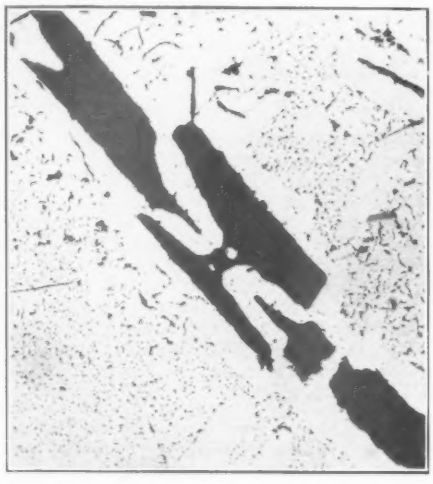


FIG. 8. × 100.

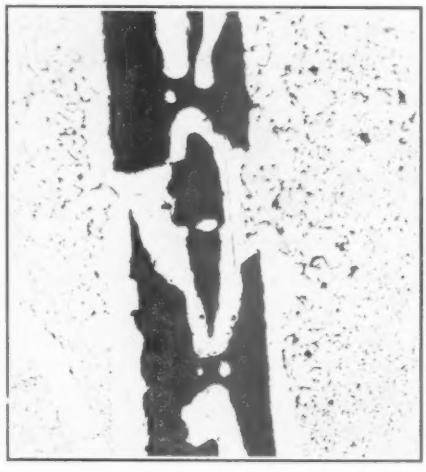


FIG. 9. × 100.

FIGS. 8 AND 9 SHOW GRAPHITE FLAKES FRACTURED IN THE MELT DURING FREEZING.

FIG. 10. ×100.

FIG. 11. × 100.

FIGS. 10 AND 11 SHOW THIN GRAPHITE FLAKES BROKEN AND AFTERWARDS SEMI-COALESCED.

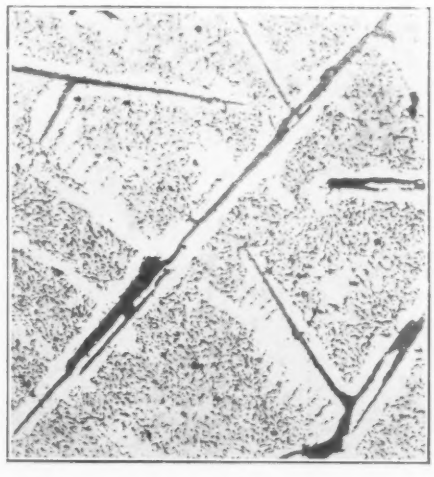


FIG. 12.—SHOWING GRAPHITE WITH LATERAL AGGREGATIONS CONFORMING TO CRYSTALLOGRAPHIC DIRECTIONS. × 100.

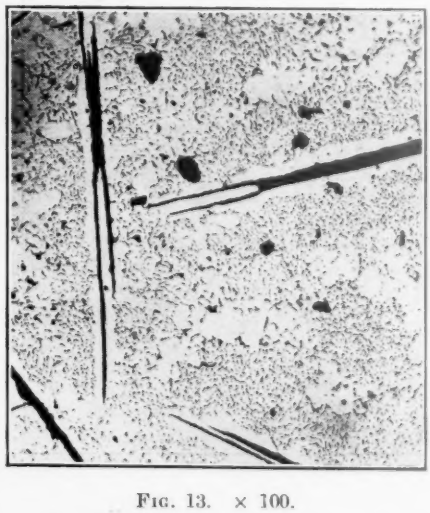


FIG. 13. × 100.

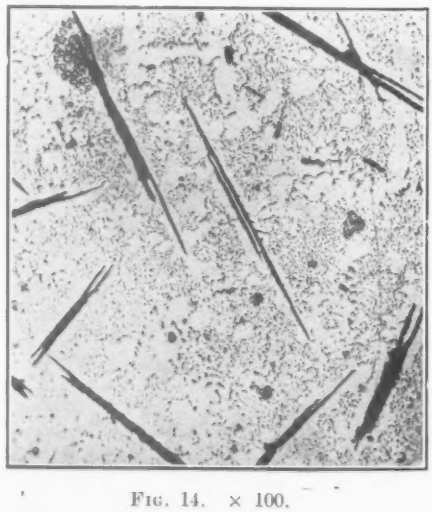


FIG. 14. × 100.

FIGS. 13 AND 14 SHOW NOVEL TYPE OF GRAPHITE FORMATION.

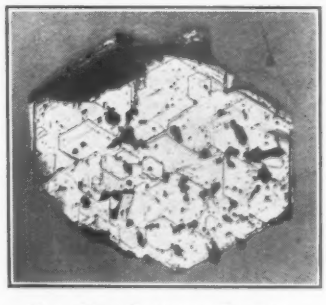


FIG. 15.—GRAPHITE LAMINA. × 30.

by Piwowarsky[8] and by Bardenheuer and Zeyen[9] can be consulted, as also that by Wagner.[10]) The effect of melting in vacuo is dealt with further on, when personal researches are detailed.

By greatly increasing the rate of the cooling, the iron can be obtained white; it is brought down to freezing point subsequently to the

metastable range, and is therefore completely undercooled.

The very marked effect which furnace walls have upon the graphite formation may again be referred to. Fig. 1 shows, under a magnification of 100 diameters, the long graphite lamellæ which proceed from the walls of a graphite crucible. The shaking of the melt materially hinders undercooling.

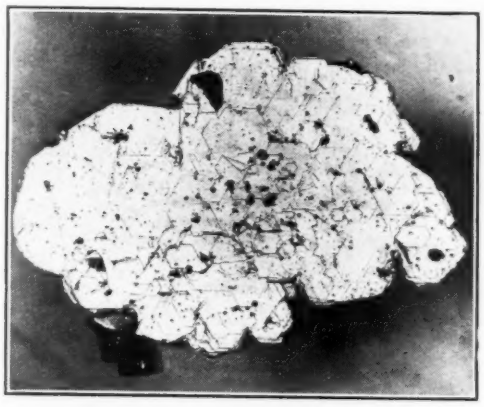


FIG. 16.—GRAPHITE LAMINA. × 30.

Having stated in the above in a general way the most important factors which favour or hinder undercooling, it is now proposed to deal with the question as to how freezing without and with undercooling operates upon the graphite formation in cast iron. The question is divided under three main headings, namely, hypo-eutectic, eutectic, and hyper-eutectic alloys.

Hypo-eutectic Alloys

(1) When a hypo-eutectic iron alloy freezes without marked undercooling then, in the first place, a primary solid solution will separate out in conformity with the lines of the equilibrium diagram. When the residual melt has reached the eutectic composition then more or less large graphite lamellæ will be formed, besides further solid solution, according to the quantity of residual heat and the freezing time this requires. In such instances, the structure hardly reveals a primary dendritic formation, and this all the less the nearer the composition of the melt approaches to the eutectic.

(2) When a hypo-eutectic alloy freezes with marked undercooling, then also will a primary solid solution separate out in the first place, in conformity with the lines of the equilibrium diagram. This separation continues also when the eutectic composition of the residual melt is reached, since the separation of the graphite sets in with a higher undercooling. The residual heat becomes first hyper-eutectic, and with a greater number of nuclei freezes suddenly to an extremely fine mixture of fine graphite and solid solution. Thus, in isolated portions of the melt at which undercooling has first been arrested, there may grow in the melt graphite crystals in the form of radiating stars. The dendritic structure increases markedly with a decrease in total carbon percentage. The fine grain graphite is arranged and interleaved in a decided reticular structure. The mechanical properties of these alloys correspond to the higher carbon percentages, the feature in this instance being a lamellar irregular embedded graphite eutectic, which characterises alloys of this composition frozen without any marked undercooling.

FIG. 17.—COARSE GRAPHITE SHOWN IN FIGS. 10 AND 11 VIEWED UNDER POLARISED LIGHT.

FIG. 18.—COARSE GRAPHITE FLAKES CORRESPONDING TO FIG. 7, VIEWED BETWEEN CROSSED NICOLS.

Eutectic Cast Iron

(3) Eutectic cast-iron alloys which freeze without any marked undercooling show, in accordance with the longer period of growth, more or less coarse graphite lamellæ irregularly arranged.

(4) The eutectic graphite can become fine and extremely fine by a heavy undercooling. When there is a large number of nuclei, crystallisation which commences suddenly and ends rapidly does not allow a growth of the graphite nuclei. This condition is illustrated further on, when showing the structures of the hyper-eutectic melts experimentally made.

(5) Hyper-eutectic melts which freeze without marked undercooling first separate out coarse graphite (it is proposed to deal solely with freezing in regard to the stable system). When the residual heat attains the eutectic composition, then the case is one for normal and more or less coarse graphite formation—together with saturated solid solution—determined by the duration of growth. The graphite flakes are quite irregularly arranged.

Undercooled Hyper-eutectic Action

(6) When the crystallisation of hyper-eutectic melts takes place with heavy undercooling, the primary graphite lamellæ can grow very markedly. The eutectic composition of the residual heat is made to fall and there may even occur the formation of primary solid-solution dendrites. These, in many cases, start from the primary graphite flakes. The residue then freezes very rapidly to exceedingly fine graphite and saturated solid solution.

Micro-Structure of Graphite

The microphotographs reproduced here apply to a series of cast-iron melts produced at a temperature of about 1,640 deg. C. in a high vacuum (below 0.0001 mm. pressure) in carbon crucibles (melting time 20 min. and over, cooling time about 2½ hrs.). The melts were superheated and very clean, were specially free from gas, and hence inclined to heavy undercooling.

The illustrations have a magnification of 100 diameters, and Fig. 2 shows parts of two large graphite lamellæ (Kish). Some of the lamellæ reach a length of 8 mm. ($\frac{5}{16}$ in.). The eutectic graphite separation is extraordinarily fine and

granular, corresponding to the high undercooling. The haloes surrounding the graphite lamellæ are lamellar pearlite.

Figs. 3 to 6 show well-defined dendrites of primary crystals in hyper-eutectic melts, which, in part, clearly take their start from the Kish graphite flakes.

FIG. 19.—SHOWS FRACTURED GRAPHITE FLAKE VIEWED BETWEEN CROSSED NICOLS.

FIG. 20.—NOVEL FORMATION OF GRAPHITE VIEWED BETWEEN CROSSED NICOLS.

Fig. 7 shows course graphite (Kish) which has grown radiating from a nucleus in the melt.

Figs. 8 and 9 illustrate Kish graphite lamellæ with peculiar fracture phenomena. These fractures have been caused by bending and pressure stresses occurring in the melt when liquid and when freezing. The graphite flakes here seen have a length of 6 to 8 mm. ($\frac{3}{16}$ in. to $\frac{5}{16}$ in.).

Figs. 10 and 11 show thin coarse graphite lamellæ (Kish) which have been broken up by working the melt, and have been thrust aside and collected together again like drift-wood.

Fig. 12 shows coarse graphite lamellæ with lateral aggregations which correspond to crystallographic axes and enclose definite angles.

Figs. 13 and 14 are most interesting from the crystallographic standpoint. The longitudinally-sectioned small graphite flakes have somewhat the shape of double tuning forks. Owing to the impoverishing of the mother-liquor in carbon and to insufficient diffusion, the graphite flakes have quickly grown superficially at the ends, whilst the nucleus has not moved. This formation of a border apparently cleaved all round is of frequent occurrence in the case of minerals having a similar crystallisation, together with a rapidity of growth largely prevailing in one direction. This phenomenon had not been observed so far in regard to graphite in cast iron.

Examination of Graphite *per se*

With reference to the structure of the graphite lamellæ in cast iron, this also will be dealt with in a general way only. Graphite is a wholly opaque, hexagonal mineral having a good reflecting power. According to the work by P. Ramdohr,[11] the examination of graphite can easily be carried out in polarised light. With finely-granular graphite, there is no difficulty in making the polished section. It is sufficient to give the specimen a preliminary polish by hand, wet, on a stationary glass disc, and to finish polishing by rubbing round gently on a cloth-covered block. Coarse graphite, also in the case of polished sections of cast iron, have repeatedly to be treated hot with kollolith or another similar sealing-wax preparation. Slipping on the hexagonal basis (0001) occurs so very easily that the grinding of a basal section of cast iron is almost impossible and produces exfoliation. The small and mostly peculiar-shaped graphite plates and graphite flakes in cast iron, when examined with a polarising system, show a decided reflex pleochroism. When in the case of the graphite lamellæ the run of the basis is in the longitudinal direction of the strip-shaped section parallel to the plane of vibration of the nicols, their luminosity is as great as with basal sections. Luminosity is lowest perpendicular to the plane of vibration of the nicols. On turning the section between crossed nicols, a fourfold extinction is observed.

Fig. 15 shows a coarse graphite lamina under a magnification of about 30 diameters. The hexagonal shape is shown to have been well maintained. Reflectivity, as already mentioned, is good, and with reference to orientation is independent of the revolution of the specimen.

Another graphite lamina is illustrated in Fig. 16; this is of larger proportions, but is in poorer condition. The outline of the upper surface and of the edges is very distinct.

The radiographic researches made by Wever show that the crystal size of the graphite lamina in cast iron is of about 100 Angstrom units, corresponding to about half that of temper carbon. When viewing the strip-shaped sections through the graphite laminæ with crossed nicols, small graphite lines became uniformly extinguished. The coarse graphite fragments reproduced in Fig. 17, which correspond to those of Figs. 10 and 11, but taken in polarised light, also show—apart from faulty polished parts—approximately the same behaviour. The circumstance may be due to the fact that individual lamellæ are built-up of parallel, microscopically small particles giving the impression of uniformity.

Fig. 18 shows coarse graphite between the crossed nicols, corresponding to Fig. 7.

Figs. 19 and 20 illustrate between the crossed nicols the fragments on coarse graphite flakes, already referred to, also the peculiar-shaped end of a graphite lamella. The pressure and bending stresses in the graphite generated during the cooling of the cast iron (there arising a substantially small shrinkage) cause an upsetting and crumpling of the individual graphite lamellæ; hence their wavy character. While lamellar graphite in cast iron always consists of small basal plates, the microscopic examination of temper carbon showed that here was a revelation of a conglomeration of fine graphite layers, round fibrous aggregates, in which the basis of the small laminæ is oriented perpendicular to the radius of the sphere. This is dealt with in detail later.

Influence of Graphite on the Properties of Cast Iron

With reference to the influence which the amount, form and arrangement of the graphite have upon the properties of cast iron, the following general observations may be made:—

The difficulties in the casting technique and in machining increase markedly with a lowering of the carbon and graphite percentages. As far as possible, therefore, the carbon content of cast iron must not go below a determined value. Graphite in globular formation is the most favourable. The "notch" effect is of the least importance in such cases, and the superficial

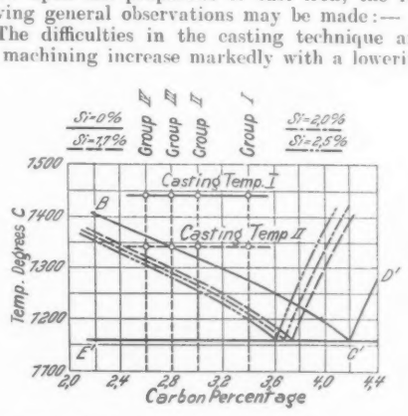
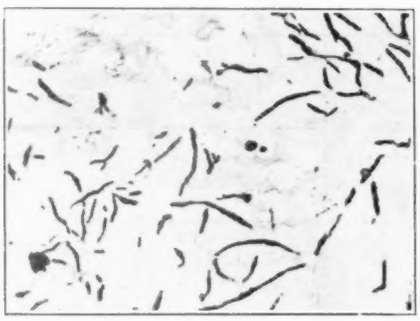


FIG. 21.—POSITION OF CASTING TEMPERATURES IN EXPERIMENTS BY KOCH AND PIWOWARSKY WITH RESPECT TO LIQUID AS LINES OF VARIOUS FE-C-SI ALLOYS (CONSTRUCTED ON C' D' LINES DETERMINED BY PIWOWARSKY AND SCHICHTEL FOR DIFFERENT SI CONTENTS).

area corresponds to a' minimum. A small number of large spheres would weaken the material at isolated parts to such an extent that fractures would easily occur. An exceedingly large number of the smallest spheres, hence a highly-dispersed distribution, would mean a much too great superficial lack of continuity in the material. The best solution lies between the two extremes. The superficial area of the graphite has to be in the most favourable proportion to the quantity present in the mass. Short, thick lamellæ, not connected too closely to one another, and not too numerous, are the most favourable form (the globular form of carbon deposition can only be arrived at in the case of malleable cast iron). An unfavourable graphite formation, of fine, connected shapes, the superficial area being large, even when occurring in the wide meshes of a network, as, for instance, in highly undercooled, highly hypo-eutectic melts, is of a nature fully to determine the mechanical properties. Fracture proceeds along the meshes and goes from one graphite flake to another.



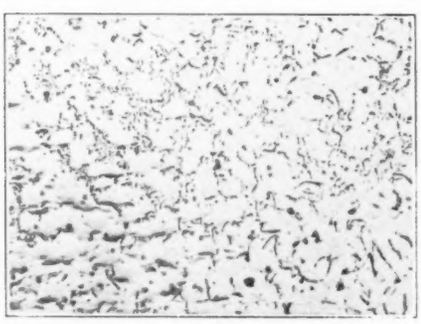


FIG. 22.—STRUCTURES OF THREE DIFFERENT CAST IRONS WITH WIDELY DIVERGENT GRAPHITE FORMATION OBTAINED IN WEAR TESTS ON C.I. FOR AUTOMOBILE CYLINDERS BY WALLICHS AND GREGOR. *Top*: SAMPLE No. 22; *Middle*: SAMPLE No. 32, AND *Bottom*, SAMPLE No. 41. ALL THE MICROS ARE UNETCHED. × 75.

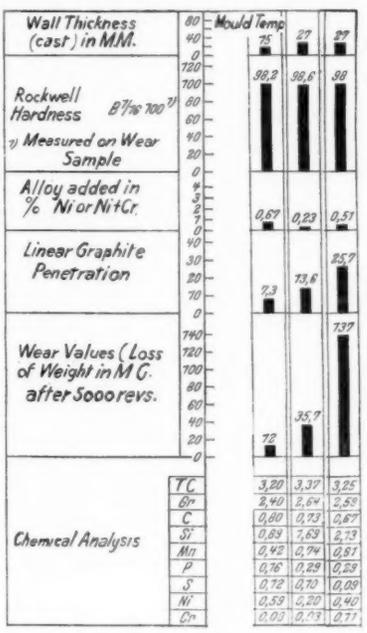


FIG. 23.—WEAR VALUES OF THREE AUTOMOBILE CYLINDER IRONS OBTAINED BY WALLICHS AND GREGOR WITH A WEAR-TESTING MACHINE.

Reference may now be made to a few, mostly recent, researches dealing with the influence which the form and amount of graphite have upon the properties of grey cast iron, researches which for the most part have been carried out in Aachen.*

A. Koch and E. Piwowarsky[12] carried out a very complete investigation on the influence of the carbon content upon the structure and strength properties of grey cast iron, with reference to varying silicon contents, temperatures and wall thicknesses.

They were able, generally, to confirm former results. The graphite content rose, and its formation was coarser with an increasing wall thickness; the transverse and tensile strengths also fell in somewhat the same proportions. For the same superheat, alloys the poorer in carbon could, naturally, be less undercooled; in the eutectic graphite crystallisation, the formation of a reticular, exceedingly fine granular graphite structure having a too-large superficial area did not occur, but, owing to the lesser undercooling, there ensued the formation of more or less irregularly divided, highly-grown fine graphite lamellæ. The impact strength, in particular, of several alloys was found to have increased eight to ten times.

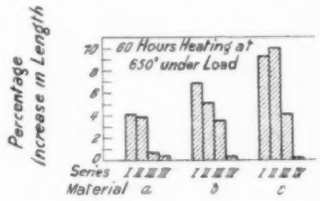


FIG. 24.—EFFECT OF VARIOUS TYPES OF GRAPHITE FROM BORNHOFEN AND PIWOWARSKY.

Fig. 21 shows the casting temperature worked to by Koch and Piwowarsky, along the lines established by Piwowarsky and Schichtel[13] in the iron-carbon-silicon diagram.

Wear Tests

The reports by Heimes and Piwowarsky[14] on researches on cast iron, using a new type of wear-testing machine, clearly show that with graphite of increasing fineness, the structural composition being generally the same, wear largely increases in all classes of wear tests, namely, rolling and sliding friction, friction by rotation in an emery bush, and friction by cutting-in with a mild-steel disc. The structure becomes gradually more broken up, and in rolling friction especially frictional oxidation (Fink)[15] is greatly increased. In the case of dry sliding friction the graphite acts as a lubricant; in this

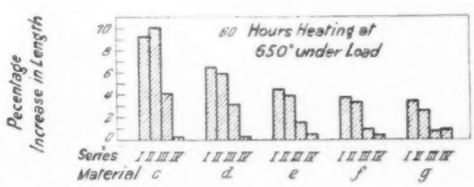


FIG. 25.—FORMATION DETERMINED BY COMPOSITION OF THE MELTS ON THE GROWTH OF VARIOUS CAST IRONS.

FROM BORNHOFEN AND PIWOWARSKY.

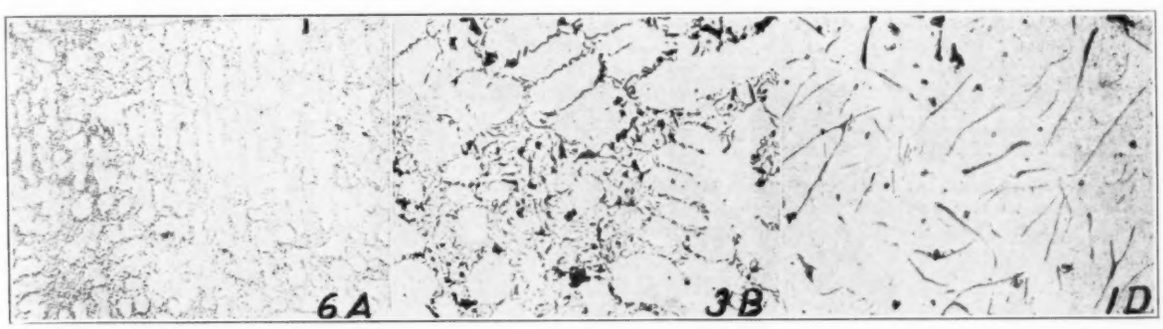


FIG. 26.—CHARACTERISTIC STRUCTURES OF THREE CAST IRON TESTS BY NIPPER AND PIWOWARSKY FOR THEIR CORROSION RESISTANCE EXPERIMENTS. THE LETTERS INDICATE CORRESPONDING SAMPLES IN FIG. 27.

* Opportunity is here taken to state that when in the course of this paper reference is made to a few research results mostly proceeding from Aachen, the author in no wise loses sight of the importance of the exceedingly numerous other researches in the same field, carried out both in foreign countries and in Germany. The present short paper can only cover a part of the subject; the references made are simply those which concern this same part.

instance, there occurs a most favourable graphite content and a most favourable graphite formation. When the graphite content is too high and also too fine, the structure breaks up. Of all the graphite arrangements, well-formed and relatively coarse temper carbon showed the lowest wear values. A ferritic structure, together with a relatively largely increased graphite segregation wears away much more than a purely pearlitic one. The influence of other alloy elements, apart from that which they have upon the carbon content and the structure, was not clearly ascertained.

Like Heimes and Piwowarsky, Wallichs and Gregor,[16] in their wear tests of various classes of cast iron for motor-car cylinders, using wear-testing machines and heavy traction engines, found that wear directly increases with increasing linear graphite dissemination. Following extensive ascertainments by Wallichs and his co-workers, hardness influences the resistance to wear of the test specimens, and can remain constant.

Fig. 22 shows the structure of three pearlitic brands of cast iron; it is unetched. Fig. 23 illustrates the results of wear for the same class of material. The work in this connection shows that a metal exhibiting definitely good lamellar pearlite with, in itself, a low carbon content, and a moderate linear graphite dissemination, gives the lowest wear valves and is easy to machine. The required structure can be arrived at by hot pouring in pre-heated moulds, the percentages of carbon and silicon being low.

In the course of their work, Bornhofen and Piwowarsky[17] have carried out researches to ascertain the influence of nickel and silicon, also of the graphite content and formation upon the growth of cast iron. Heating-up for 60 hrs. to 650 deg. C., therefore, under the A point showed very clearly that annealed chill-cast bars, having well-developed temper carbon, behaved the best. The main structure was ferritic. Pearlitic specimens, especially those showing a coarse graphite formation, exhibited by far the greatest growth (see Table I and Figs. 24 and 25). Silicon influences growth by the manner in which the graphite formation takes place. According to Bardenheuer,[18] following his researches with silicon steels, silicon has a greatly retarding action upon growth. It has quite the same effect in the case of chill castings, whilst in that of a pearlitic structure and, to a smaller extent, in that of a ferritic-graphitic structure, it favours growth. The formation of SiO_2, promoted by more or less deep penetration of gases along the coarse graphite plates, can here be taken into

TABLE I.—*Summary of Chemical Composition, Mechanical Properties, and Structure of various Cast Irons studied by Bornhofen and Piwowarsky.*

Melt No.	Composition.[1]			Properties of dry cast bars of 33 mm. diam.				Series I. Pearlite with fine lamellar graphite 0.002 to 0.2 mm.		Series II. Pearlite with coarser graphite 0.03 to 0.2 mm.		Series III. Ferrite with coarse graphite.[3]		Series IV. Graphite like temper carbon[3].	
	C	Si	Ni	Tensile strength. kg./mm.²	Transverse strength kg./mm.²	Brinell hardness.	Specific Gravity.	Bar.[4]	Carbide content.	Bar.	Carbide content.	Bar.	Carbide content.	Bar.	Carbide content.
(*a*) ..	3,08	0,94	—	25,9	42,7	212	7,3976	T 33	1,52	T 50	1,50	T 50	0,04	K 33	0,04
(*b*) ..	3,03	1,74	—	24,2	37,8	196	—	N 33	1,29	T 50	1,20	T 50	0,04	K 33	0,04
(*c*) ..	3,07	2,52	—	19,8	33,5	199	7,3312	N 20	1,22	N 50	1,18	N 50	0,00	K 20 / K 33	0,02
(*d*) ..	2,90	1,77	0,90	25,1	37,2	199	7,4037	N 20	1,23	N 50	1,26	N 50	0.03	K 20 / K 33	0.04
(*e*) ..	2,92	1,25	1,85	27,1	—	—	7,4423	T 20	1,32	N 50	1,29	N 50	0,04	K 20 / K 33	0,06
(*f*) ..	3,10	0,73	3,70	27,0	42,7	222	7,4380	N 33	1,24	N 50	1,20	N 50	0,03	K 33	0,06
(*g*) ..	3,09	0,32	5,63	27,9	43,2	225	7,4724	N 33	1,26	N 50	1,28	N 50	0,06	K 33	0,34
(*h*) ..	3,06	0,38	3,95	29,6	42,5	237	7,4848	N 33	1,46	T 50	1,42	T 50	0,02	K 20	0,08

[1] Average Mn 0.03; P 0.02 and S 0.015 per cent. [2] Bars as Series II annealed between 650 and 800 deg. C. [3] Bars annealed in coal-sand mixture for 1 hr. at 1,050 deg. C., and several times between 600 and 800 deg. C. [4] T = Dry sand casting; N = Green sand casting; K = Chill casting. The figures denote the diameter of the cast bars in mm.

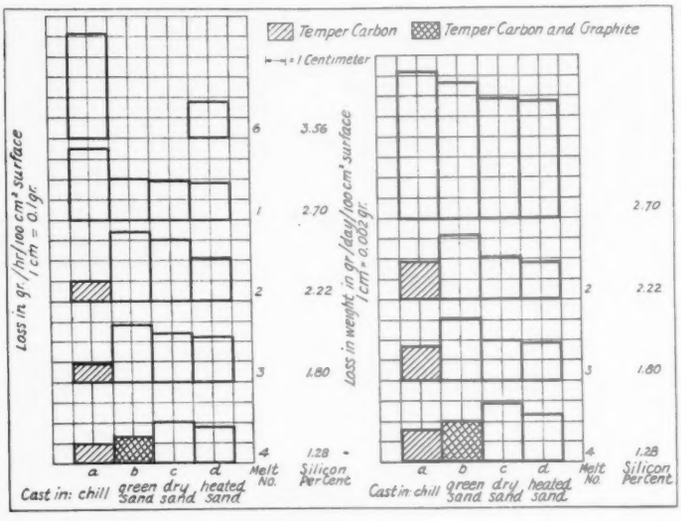


FIG. 27.—CORROSION ATTACK BY NORMAL HYDROCHLORIC ACID AND WET SOIL RELATED TO GRAPHITE CONDITION OF VARIOUS TYPES OF CAST IRONS OF THE FOLLOWING COMPOSITIONS:—

Melt No.	T.C.	Gr.	Si.	Mn.	S.	P.
6	2,8	2,80	3,56	0,41	0,025	0,059
1	3,05	3,03	2,70	0,40	0,024	0,053
2	3,04	3,02	2,22	0,40	0,024	0,058
3	3,02	3,00	1,80	0,40	0,024	0,058
4	3,03	3,02	1,28	0,41	0,024	0,054

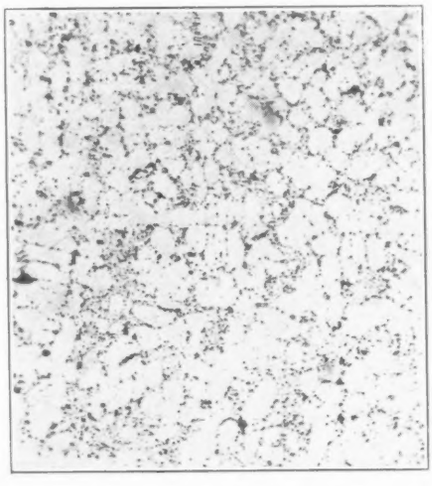


FIG. 28.—GRAPHITE STRUCTURE OF TWO CAST IRONS OF SIMILAR COMPOSITION (C 3.04, Si 2.28, AND Cu 1.92) EXAMINED BY SÖHNCHEN FOR THEIR PHYSICAL PROPERTIES. *Top*: SAND CAST, HEAT TREATED, UNETCHED. × 100. *Bottom*: CHILL CAST, HEAT TREATED, UNETCHED. × 100.

(*Concluded on page* 14.)

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Contribution to the Study of Graphite Formation and Structure in Cast Iron and its Influence upon the Properties of the Cast Metal.

(*Concluded from page* 12.)

account and made responsible for the extensive growth. Figs. 26 and 27 show from the work by Nipper and Piwowarsky[18] the characteristic structure of three cast-iron brands (unetched). Both in a semi-normal hydrochloric-acid solution and in damp earth a high linear graphite dissemination, in contrast to temper carbon, and also to short and thick graphite flakes, brings about corrosion. In damp earth, the difference is somewhat less marked.

In conclusion, the results of quite recent researches made by E. Söhnchen in the Giesserei-Institut, which are destined to show the influence of the graphite formation upon some physical properties, are shortly dealt with.

Fig. 28 gives the structure and analysis of a test specimen cast in sand and of one chill cast. The material is ferritic annealed. Table II gives

TABLE II.—*Effect of Graphite Formation in two Cast Irons of a similar Composition on various Properties, according to Söhnchen.*

Properties.	Sand Casting. Reheated.	Chill Casting. Reheated.
Graphite formation :	Coarse	Fine
Coercivity (Oersted)	5,6	7,2
Remanence (Gauss)	6,360	8,400
Saturation (Gauss)	18,900	18,700
Thermal conductivity (Ni=1) ..	0,94	0,69
Electrical conductivity .. .. (Ω^{-1}. cm^{-1})	$1,39.10^{-4}$	$1,71.10^{-4}$
Percentage loss in weight :		
N/5 HNO_3 (10 days)	11,0	12,4
N/5 acetic acid (10 days) ..	9,5	10,2
Air (50 days)	0,62	0,81

the magnetic properties, figures for heat and electricity conductivity, also a few corrosion results. The following may be added, briefly, in this connection.

The coercivity, which is comparatively high owing to the Cu content of the melt, is still further increased by the very fine heterogeneous components which are precipitated (graphite in chill casting), which conforms completely with observations made with various magnet steels. The remanence is also much higher with fine graphitic formations, while the saturation is not affected, which agrees with the observed effect of various carbide formations in steels. The thermal conductivity, which is affected to a much greater degree by the particle size than the electrical conductivity, on the other hand, decreases, which is evidently mainly due to the finer nature of the ferrite grains, the electrical conductivity increases with the fineness of the precipitated components, in line with common observation.

Corrosion tests carried out on laminæ 20 mm. dia. and 5 mm. thick confirm the results of Nipper and Piwowarsky. Corrosion increases with an increase in the fineness modulus of the graphites.

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The Institute of British Foundrymen

LIST OF MEMBERS WHO ATTENDED THE ANNUAL CONFERENCE HELD AT MANCHESTER, JUNE, 1934

Affleck, J., Clarkston; Andrew, F., Manchester; Andrew, Prof. J. H., Sheffield; Athey, Major J. W., Birmingham; Auckland, W., Bolton; Baker, I. H., Wolverhampton; Barlow, E. P., Sheffield; Bayley, A., Crewe; Bayne, J., Prescot; Bedford, J., Bolton; Beech, A. S., London; Bell, Jas., Gateshead; Bell, John, Glasgow; Bigg, C. W., Derby; Bird, Major T. G., Gateshead; Blakiston, J., Middlesbrough; Bolton, L. W., Birmingham; Brooks, S., Stockport; Brown, W., Manchester; Bunting, H., Derby; Burder, K. M., Loughborough; Burgess, A., Stockport; Burgess, C. J., Port Talbot; Butters, F. G., Uttoxeter; Button, L. J., Crewe.

Cameron, J., Kirkintilloch (Past-President); Campion, A., Bearsden; Carlisle, E. A., Sheffield; Carter, S., Huddersfield; Coggon, H. F., Halifax; Cook, F. J., Birmingham (Past-President); Cook, W. N., Manchester (Lancashire Branch-President); Cooke, J. E., Manchester (Conference Secretary); Cooper, J. H., Darlington; Cooper, W. R., Walsall; Cowan, H., Falkirk; Cowgill, T., Manchester; Crawley, E. J., Sheffield; Cree, F. J., Rochester; Daniels, W., Bolton; Delport, V., London; Demaine, F. C., Oldham; Dobson, W. E., London; Donaldson, Dr. J. W., Greenock; Doughty, E., Manchester; Durrans, J., Penistone; Durrans, P. H., Penistone.

Edwards, A., Cheltenham; Eltoft, N., Accrington; Evans, S., London; Evans, T., Prescot; Everest, Dr. A. B., London, Faulkner, V. C., London (Past-President); Firth, A., Sheffield; Flower, E., Manchester; Fontaine, C., Newport; France, G. E., Halifax; Gardom, J. W., Birmingham; Gilpin, W., Manchester; Goodwin, J. T., Chesterfield (Past-President); Goodwin, T., Derby; Greaves, E. C. S., Leeds; Griffiths, G., Birmingham; Griffiths, W. T., London; Grundy, H. V., Manchester; Hadfield, S., Birmingham; Haigh, B., Manchester; Handley, R. L., Manchester; Hargraves, R. R., Manchester, Harley, A., Coventry (Past-President); Harper, H., Castleton; Harrison, A. G., Wolverhampton; Harrison, S. G., Manchester; Hartley, W. H., Leeds; Hinton, A. J., Oldham; Hird, B., Newport; Hird, J., Birmingham; Hodgson, A., Manchester; Hogg, J., Burnley; Holland, W., Manchester; Holt, L., London; Hopwood, A., Manchester; Howard, E. J. L., Manchester; Hoy, R. E., Hull; Hudson, F., Kilmarnock; Hurst, J. E. Sheffield (Senior Vice-President); Hyde, J. R., Newcastle; Ireland, S. L., Birmingham.

Jackson, J., Accrington; Jones, J. C., Workington; Jones, R. A., Manchester; Kain, C. H., London; Kenyon, H. W., Accrington; Key, A. L., Manchester; King, E. G., London; King, H. E., Nottingham; Lake, W. B., Braintree (Hon. Treasurer); Laverton, W. T., Stoke-on-Trent; Little, J. E. O., Doncaster; Lockwood, H. W., London; Logan, A., Newcastle; Longden, E., Manchester; Lord, E. S., Rochdale; Loxton, C., Leeds; Lucas, J., Loughborough; Lunt, G. T., Wolverhampton.

Machin, W., Barrow-in-Furness; Makemson, T., Manchester (General Secretary); Markland T. W., Bolton; Martin, R. A., London; Masters, J., Shrewsbury; Meadowcroft, W. H., Burnley; Miles, R. A., Manchester; Mills, H., Oldham; Moir, D. M., Birmingham; Molineux, W. J., Wolverhampton; McArthur, J., Motherwell; McClelland, J. J., Bilston; McGrah, F. E., Wolverhampton; Neath, F. K., Keighley; Nipper, Dr. H. A., Aachen; Norbury, Dr. A. L., Birmingham; O'Keefe, W., Birmingham; Oldham, M. C., Barrow-in-Furness; Otto, C., Manchester; Owen, E., Bury; Owen, S., Liverpool; Pearce, J. G., Birmingham; Pearson, S., Birmingham; Phillips, A., Manchester; Phillips, H., Wednesbury; Pittaway, F. J., Lincoln; Pollard, C. D., Scunthorpe; Pollard, W., Burnley; Prescott, A. A., Manchester; Primrose, J. M., Falkirk; Primrose, J. S. G., Manchester; Pyatt, W., Leicester.

Raundrop, G. P., Manchester; Rawlinson, W., Manchester; Reynolds, J. A., Prescot; Richardson, W., Manchester; Ridsdale, N. D., Middlesbrough; Riley, N. W., Harrogate; Robertson, J., Coatbridge; Robertson, W., Bearsden; Robins, C. H., Kettering; Rowden, W. F., Warrington; Rowe, F. W., Huddersfield; Roxburgh, J., Sheffield; Russell, F. S., Sheffield; Russell, P. A., Leicester.

Sayers, H., Leeds; Schofield, H., Newcastle; Scott, W., Monkseaton; Selkirk, W. L., Birmingham; Senior, G., Sheffield; Sharpe, D., Glasgow; Shaw, J., Southsea; Sheehan, J. J., Birmingham; Shirt, F. A., Sheffield; Sillavan, J., Manchester; Skerl, Dr. J. G. A., Sheffield; Smeeton, J. A., London; Smith, S. G., Manchester; Smith, W. H., Birmingham; Spriggs, R., Loughborough; Stobie, V., Harrogate (Past-President); Stott, B. E., Warrington; Stubbs, Roy, Manchester (President); Studley, G. C., Manchester; Sutcliffe, A., Bolton; Talbot, P., Erith; Tate, C. M., Burnley; Tate, W. G., Burnley; Taverner, G. B. R., London; Thomson, C., Manchester; Thompson, M. D., Aldridge; Thompson, T. E., Rochdale; Tipper, A., Birmingham; Tomlinson, H., Castleton; Turner, A. C., London; Turner, T. H., Doncaster; Twigger, T. R., Coventry; Wass, O., Sheffield; Wharmby, J. T., Manchester; Whiteley, A., Sheffield; Wicker, H., Castleton; Wilkinson, T., Stockton-on-Tees; Wilks, L. P., Wolverhampton; Williams, C. E., Cardiff (Immediate Past-President); Williams, F. G., Calcutta; Williams, R. A., Hanley; Williamson, W. H., Rochdale; Wilson, R., Wednesbury; Wilson, W. R., Liverpool; Winter, N. F. S., Halifax; Winterton, B., Chesterfield; Winterton, H., Milngavie (Junior Vice-President); Wood, D. H., Birmingham; Wood, J. F., Wellingborough; Zirker, Dr. G. H., London.

Use of Ni-Resist Mandrel Contributes to Solution of Rotary-Drier Problems

Heat-resisting nickel-alloy cast iron has solved an important problem in the design of a rotary drier of novel design, according to the "Nickel Cast Iron News" of March, 1934. The unit consists of a direct-fired heating mandrel, spring-suspended to allow for expansion and contraction, and a return heat deflector which creates natural drying currents within the drier. The material being dried is advanced through the machine by the rotation of the cylinder, which is set at a suitable slope, while the inner mandrel revolves with the outer shell. Lifting flights on the inside of the outer shell lift the material to be dried and cascade it through the heated moisture-absorbing gases on to the hot mandrel. Complete exposure of the material is thus procured with maximum heat transfer to the wet material. The requirement for high resistance to growth, scaling and cracking in the mandrel had been only partially met until the use, in 1932, of Ni-Resist. This innovation is considered to have "removed the last disadvantage in double-shell rotary driers," and it is now being introduced on a commercial scale. In addition to the mandrel, the flights or paddles of the drier are now made from Ni-Resist, and a martensitic nickel-chromium iron of special wear-resisting properties is used for the trunnions.

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XUM

This Week's News in Brief

Trade Talk

THE HOLIDAY FUND of the employees of Carron Iron Works, Falkirk, amounting to £5,803, was disbursed prior to the start of the annual holidays on June 28.

THE NEW COASTING STEAMER "Broom," built by Messrs. Scott & Sons, Limited, Bowling, for the Frontier Town Steamship Company, Limited, Newry, has completed successful trials on the Clyde.

SALARY CUTS, which, owing to the slump, had to be made in April, 1932, have been restored by Messrs. James Keith & Blackman Company, Limited. They are also starting a new light-castings foundry to keep up with the demand for that class of casting.

MESSRS. HARLAND & WOLFF, LIMITED, launched from their Belfast yard the motor vessel "Waipawa," the second vessel of the group now building for the London-New Zealand service of the Shaw Savill & Albion Company. She is 535 ft. in length and has a 70-ft. beam, with a gross tonnage of 10,860.

ORDERS FOR TWO NEW VESSELS have been placed by the L.M.S. Railway Company, one with Messrs. Denny Bros. & Company, Limited, Dumbarton, and the other with Messrs. Harland & Wolff, Limited. The Dumbarton vessel, which is a cargo- and live-stock-carrying steamer for service on the Holyhead and Dublin (North Wall) route, is to be 309 ft. 6 in. in length and 44 ft. 6 in. breadth, moulded. It will have a cattle-carrying capacity of 660 head. The other vessel, which will be built at Belfast, is a passenger, cargo and livestock steamer for the Heysham and Belfast service, and will be of the twin-screw geared-turbine propelling type, 349 ft. long, with a speed of 21 knots.

THE GAS LIGHT & COKE COMPANY, LIMITED, have designed a new fish-frying range of revolutionary type, which they intend shortly to place in the hands of a manufacturing company. The "G.L.C. Pedestal Fryer," as it is called in its experimental stage, is cast in one piece, with an entire absence of corners or grooves, and the pan cover of stainless steel rolls backwards and forwards along stainless steel rails. A double casing is incorporated, which by means of a substantial down-draught through the pedestal effectually rids the restaurant of fumes. The range was originally planned for Mr. Claude Hulbert, the famous film and wireless comedy actor, who wished a cleaner and more attractive range for a shop which is to appeal to a "better-class" clientele.

AN EVENT recalling pre-war prosperity in the shipbuilding industry took place in Aberdeen this week, when two vessels were launched from different yards. This is the first occasion for some years that two vessels have been launched on the same day in Aberdeen. Messrs. Alexander Hall & Company, Limited, launched the steel-screw harbour and seagoing tug "Bonsecours," built to the order of the James Dredging, Towage & Transport Company, Limited, London and Southampton. The other vessel was an auxiliary yacht, from the yard of Messrs. Hall Russell & Company, Limited, the "Trenchemer," built specially for ocean racing to the designs of Mr. Olin J. Stephen, of New York. She is built of steel and the first yacht built in this country for the purpose under the 55-ft. rating class of the Royal Ocean Racing Club.

THE FALKIRK TRADES HOLIDAYS commenced with the closing of foundries and factories on June 29, and the better conditions prevailing in the light-castings industry is reflected in the fact that the vacation generally is to be of no more than a week's duration. The resumption in most cases is fixed for Monday, July 9, and only in a few cases is it delayed until the following day. It is true that for some weeks past work at the foundries has not been quite so brisk as it was at the beginning of the year, but compared with the same period last year work was definitely more plentiful. Whereas on the books of the Ironfounding Workers' Association at the end of June last year there were 570 members in receipt of unemployment benefit (the figure having dropped from 1,200 in the space of three months), there are now only 214 members on the out-of-work list, At the New Year the number was only 120. The report from the General Ironfitters' Association is on similar lines. With the continued activity in house building, the prospects are regarded as being quite good for some time to come.

OFFICIAL ANNOUNCEMENT has been made of the acceptance of the offer by Sir James Lithgow, Bt., to purchase the shares of the Steel Company of Scotland, Limited. The deal is expected to be completed in the very near future, as the financial year of the Steel Company ends in the middle of July, and involves about £675,000. There are 50,000 shares of £10 each issued, and it is understood that Sir James Lithgow's offer was one of £13 10s. per share. Since 1920 the shares of the Steel Company of Scotland have been held privately by a group of shipbuilders who in that year acquired them at £35 per share. The deal is intended to permit of the co-ordination of development in the Scottish steel industry, which it is desired to achieve, so that a plentiful supply of cheap steel on an economic basis may be available. It is regarded, therefore, as of outstanding interest and significance for the Scottish steel industry and for the shipbuilding and engineering industries. Sir James Lithgow is already a director of Colvilles, Limited, and William Beardmore & Company, Limited. In the meantime there is no intention of making any alteration in the management or in the production arrangements of the Steel Company of Scotland, which is an important unit in the Scottish heavy trades.

Contracts Open

Cork, July 7.—1,000 4-in. cast-iron water pipes, for the Town Council. The Waterworks Department, Fitzgerald Park.

Purleigh, July 9.—2,000 yds. of 3-in. and 5-in. cast-iron pipes, for the Maldon Rural District Council. Mr. W. Almond, engineer to the Council, 6, Market Hill, Maldon.

Siam, August 10.—200 metric tons of Cleveland No. 3 pig-iron, for the Royal State Railways. The Department of Overseas Trade. (Reference G.Y. 13,980.)

Southwell, July 12.—2,550 tons of 3-in. to 7-in. dia. cast-iron pipes and specials (Class C), for the Southwell Rural District Council. Messrs. Sands and Walker, Milton Chambers, Nottingham. (Fee £5 5s., returnable.)

London, E.C., July 24.—Eight locomotives, for the Bengal & North-Western Railway Company, Limited, 237, Gresham House, Old Broad Street, London, E.C.2.

Company Reports

Petrie & McNaught, Limited.—Payment of 4 per cent. on the 8 per cent. preference shares for the half-year ended October 31, 1930.

John Hetherington & Sons, Limited.—Loss for year ended March 31 last was £7,265, which increases the debit balance carried forward to £152,834.

Metal Traders, Limited.—Profit, £58,175; brought in, £31,473; dividend of 12½ per cent. and bonus of 5 per cent.; to reserve, £15,000; carried forward, £46,455.

Thomas Firth & John Brown, Limited.—The directors have decided to pay off three years' arrears of dividend on the preference shares dating from December 31, 1930.

Mirrlees, Bickerton & Day, Limited.—Net profit, £13,097; brought in, £8,210; preference dividend, £2,977; dividend on ordinary shares of 3 per cent., £10,834; carried forward, £7,496.

New Companies

(From the Register compiled by Jordan & Sons, Limited, Company Registration Agents, 116 to 118, Chancery Lane, London, W.C.2.)

Magnesium Metal Corporation, Limited, 95, Gresham Street, London, E.C.—Capital £50,000. To produce, manufacture and deal in magnesium.

James Hall & Sons, Limited, 10, Free School Lane, Rochester, Kent.—Capital £10,000. Engineers and ironfounders. Directors: H. J. Baker, F. Hall, A. C. Fendick and Miss A. L. Hall.

Personal

MR. THOS. VICKERS has severed his connection with the firm of Messrs. Thos. Vickers, merchants, 14, New Street, Birmingham, of which he was the founder.

MR. JAMES MOORE, for 17 years secretary to the Stirling, Falkirk and Grangemouth Divisional Labour Party, has retired. He will, however, retain his position as secretary to the Ironfounding Workers' Association.

MR. DAVID D. MCGUFFIE is at present in Greece, reorganising the iron foundry of the Glavanis Manufacturing Company, and putting down a stock-oil converter for making malleable iron, steel castings and a few alloy steels.

THE GOLDEN WEDDING of Mr. and Mrs. J. McLaughland, Fallside, St. Quivox Road, Prestwick, was celebrated at their home on June 23. Mr. McLaughland is a native of Kilmarnock, and was in the employment of Messrs. D. & J. Tullis, Limited, Kilbowie Iron Works, Clydebank, for about 30 years. Owing to ill-health he retired recently.

DURING THE MIDDAY MEAL HOUR of June 28 the workers of the Columbian Stove Works of Messrs. Smith & Wellstood, Limited, Bonnybridge, met to honour Mr. John Morris, of the warehouse department, on the occasion of his marriage. Mr. J. McClanaghan presided, and Mr. James Watson, departmental foreman, made a presentation on behalf of his fellow workers.

ON THE OCCASION of his retirement as managing director of the Atlas Steel Foundry & Engineering Company, Limited, Bathgate, Mr. J. M. Watt was the guest at a complimentary dinner last week in the Dreadnought Hotel, Bathgate, under the auspices of the directors and staff of the company and friends. Mr. A. C. Strathie, chairman of the Atlas Company, presided. Tributes were paid to Mr. Watt by the directors and others, including Provost Simpson.

Will

BATES, C. T., of Northwich, ironfounder £24,676

Company Meeting

Allied Ironfounders, Limited

The annual meeting of Allied Ironfounders, Limited, was held in London recently. MR. A. W. STEVEN (the chairman) said that their subsidiary companies had well maintained their position in the market, thus enabling them to increase the number of men employed and the volume of output. Among those departments of the business which had shown expansion he might refer to the trade in porcelain enamelled baths. The consumption of baths in this country in 1933 had exceeded all previous records. On the manufacturing side much had been done during the year to improve the equipment of their factories to cope with increased business and to enable work to be turned out at lower cost. New systems of manufacture had been installed at considerable cost, and were being developed and brought into production under expert control. They had recently acquired the old-established concern of Dobbie, Forbes & Company. They could, he thought, look back on a year of satisfactory progress and to the future with some degree of confidence.

Obituary

MR. R. B. JACKSON, formerly manager of the Siemens department of Messrs. Jonas & Colver, Limited (now part of Industrial Steels, Limited), died last week, at Sheffield. He served with Messrs. Colville & Sons at Dalzell and Clydebridge Steel Works before going to Sheffield.

WE REGRET TO ANNOUNCE the death of Mr. Walter Gibb Gray, managing director of the Steel Company of Scotland, Limited, which occurred very suddenly at his residence, Ornsay, Bearsden, near Glasgow, on June 26. Mr. Gray had been connected with the coal, iron and steel trades in Scotland throughout the whole of his business life. He represented the Steel Company in the Glasgow Chamber of Commerce, and was also a director of the chamber as a representative of the Scottish Steelmakers' Association, a member of the Clyde Navigation Trust, the Lanarkshire Coalmasters' Association, and the Federation of Iron and Steel Manufacturers.

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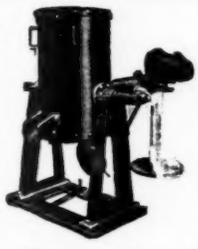

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Raw Material Markets

The position of the iron and steel industry, at the end of the half-year, gives considerable cause for satisfaction at the recovery which has been made. Outputs are generally much larger, and the industry is getting back on to a profit-making basis. The taking-up of contracts to cover the next six months has so far been somewhat backward, but there are indications that this is no more than the usual slackening off.

Pig-Iron

MIDDLESBROUGH.—Business in Cleveland foundry iron has quietened down considerably. Although the ironmasters are well booked forward, there is at the moment a small surplus output of iron, for the first time this year. This, of course, was only to be expected, in view of the holiday conditions ruling in many sections of the consuming trades. Efforts have been made to sell the surplus in overseas markets, but without much success. The autumn demand should readily absorb any stocks that accumulate over the next two months. There has been no change in quotations for the home market.

The home demand for East Coast hematite is well maintained and, in addition, export business is looking up in one or two directions. The producers still have heavy tonnages entered upon their books. Home prices continue to be based upon No. 1 hematite at 68s. per ton delivered Middlesbrough.

LANCASHIRE.—This week the annual holiday was observed in the Bolton district, and from now on there will be a succession of stoppages at various towns. The pig-iron market has naturally been affected, and there has been very little new business about. Offers of Derbyshire, Staffordshire and North-East Coast brands of No. 3 iron for delivery to users in the Lancashire zone are maintained on the basis of 74s. per ton, with Northants at 72s. 6d., Lancashire iron equal to Derbyshire quality at 74s., and equal to Northants at 72s. 6d., Scottish No. 3 at about 82s. 6d., East Coast hematite at 75s. for No. 3 and 76s. for No. 1, both unbroken, and 2s. more for breaking, and West Coast hematite 80s. 6d.

MIDLANDS.—Allowing for some seasonal slacking off, the demand for foundry iron in the Midlands has been maintained very satisfactorily as compared with recent years. Exceptionally active conditions continue to rule in the light-castings trade. There was a meeting of the Central Pig-iron Producers' Association last week, but no changes in prices were made. The present levels, delivered to Birmingham and Black Country stations, are 67s. 6d. for No. 3 Northants and 71s. per ton for Derbyshire, Lincolnshire and Staffordshire No. 3, subject to a graduated rebate for large consumers. Moderate quantities of Scottish pig-iron are consumed locally, the price for this iron being from 85s. to 87s. 6d. per ton, while low-phosphorus pig from other sources is offered at between 81s. and 85s. per ton. The price for refined iron depends on the analysis and tonnage involved, and is anything from £5 10s. to £6 15s. per ton, delivered Midland points.

SCOTLAND.—The Glasgow pig-iron market is experiencing the quietness usually associated with this period of the year. The Falkirk and district works are now closed down for the annual holidays and stocktaking, and the Glasgow Fair holiday will take place shortly. There has been no change in quotations for either Scottish or English brands of iron.

Coke

The foundry-coke market maintains a very firm tone. Many consumers have entered into contracts up to the end of the year. The following quotations are for delivery in South Staffs:—Best Durham foundry coke, 36s. to 40s.; Welsh coke, 37s. 6d. to 45s.; Scottish low-ash coke, 41s. to 42s. per ton.

Steel

Rather dull conditions continue in the steel markets, but this is characteristic of the time of the year. The home demand has become much quieter, but this is only to be expected, as stocks have been replenished and the requirements of the consuming industries have been largely provided for by forward contracts. These are keeping the works busy, although for the time being in a number of branches new business is not coming forward in sufficient volume to replace the orders which are being completed. Business in semi-finished steel has declined, but most of the works have sufficient orders on their books to keep them employed until the autumn. Recent active competition in the home market from Continental producers appears to have ceased for the time being. Irregular conditions rule in the finished-steel departments. On the whole, business is more active in the lighter branches than on the heavy side of the industry, although most of the big steelworks have a considerable tonnage of orders to deliver.

Scrap

There is a quieter demand for cast-iron scrap, but prices are generally firm. In the Cleveland area, heavy cast iron is at 50s., machinery grade at 53s. 6d. and light metal at about 45s. per ton. Conditions are unchanged in the Midlands, prices remaining firm. There is a fair demand for scrap iron in South Wales, heavy metal being at 47s. 6d. to 48s. 6d., light cast-iron scrap at 42s. to 44s., and good machinery grade, in foundry sizes, at 50s. to 52s. 6d. In Scotland, heavy machinery cast-iron scrap is at 55s., with ordinary metal at 51s. to 52s. 6d.

Metals

Copper.—Although it is believed that world stocks of this metal are gradually being reduced from their former high level, there continues to be an abundance of supplies on the London market. Prices have given way under the pressure, falling to the lowest level recorded this year. Quite a few consumers have been quick to take advantage of the low values ruling during the past week, but the buying has been insufficient to have any effect upon the general situation. One cause of the present price-cutting has been the efforts made by producers to dispose of their outputs directly to users.

Daily quotations :—

Cash.—Thursday, £31 7s. 6d. to £31 10s.; Friday, £31 5s. to £31 7s. 6d.; Monday, £31 5s. to £31 6s. 3d.; Tuesday, £30 8s. 9d. to £30 11s. 3d.; Wednesday, £30 7s. 6d. to £30 10s.

Three Months—Thursday, £31 16s. 3d. to £31 17s. 6d.; Friday, £31 13s. 9d. to £31 15s.; Monday, £31 13s. 9d. to £31 15s.; Tuesday, £30 17s. 6d. to £30 18s. 9d.; Wednesday, £30 15s. to £30 17s. 6d.

Tin.—The total visible supply of tin showed a further small reduction at the end of June, as compared with a month ago. It is estimated that an approximate balance will shortly be reached between production and consumption.

"The backwardation has reappeared, and it is evident that some interests are anxious to have as small a supply of tin available for the London market as possible. If the backwardation increases, there will doubtless be further shipments from the Continent to London to replace stocks which are steadily being moved to America," state Messrs. Brandeis, Goldschmidt in their weekly report.

Market prices :—

Cash.—Thursday, £226 5s. to £226 10s.; Friday, £225 12s. 6d. to £225 15s.; Monday, £226 15s. to £226 17s. 6d.; Tuesday, £226 5s. to £226 10s.; Wednesday, £228 5s. to £228 10s.

Three Months.—Thursday, £225 15s. to £226; Friday, £225 10s. to £225 12s. 6d.; Monday, £226 10s. to £226 12s. 6d.; Tuesday, £226 5s. to £226 7s. 6d.; Wednesday, £227 15s. to £227 17s. 6d.

Spelter.—Slightly better buying by trade users has been seen lately, and the market has a rather better tone. Activity continues in the brass industry, but conditions in the galvanising industry remain depressed and there is little prospect of an early improvement.

Day-by-day prices :—

Ordinary.—Thursday, £13 15s.; Friday, £14; Monday, £13 18s. 9d.; Tuesday, £13 15s.; Wednesday, £13 17s. 6d.

Lead.—Despite the fact that fabricators are very busy, values show no tendency to rise and the market, although steady, is very sluggish. Production in America appears to be increasing considerably and stocks at the end of May showed an advance of approximately 20,000 tons on those existing at the end of April, report Messrs. Henry Gardner & Company, Limited.

Market fluctuations :—

Soft Foreign (Prompt).—Thursday, £11 3s. 9d.; Friday, £11 2s. 6d.; Monday, £10 17s. 6d.; Tuesday, £10 15s.; Wednesday, £10 15s.

Non-Ferrous Foundry Practice

(*Concluded from page* 6.)

cured by depression of the casting temperature. If the casting were made in a chilled mould it was doubtful if the gas content would show its bad effect, but that, of course, was not always practicable; and one had to rely on getting metal reasonably free from gas content (which was likely to come out of solution) in order to eliminate any chance of inter-crystalline fissures occurring.

The CHAIRMAN wished to refer to the alpha-solid solution range; particularly with reference to the liquidus and solidus curves. There was a view gaining ground that the liquefaction of a solid solution, provided it was perfectly homogeneous, occurred when the critical speed of the vibration of the atoms in the space lattice was exceeded. Therefore the view was that the solidification point of a series of solutions should be just a single line and not a range. If Mr. Rowe was interested in the theoretical aspect of the matter, had he come across any experience that might lead him to expect that the solidus line was variable, and, perhaps, under centrifugal casting conditions was much more closely approaching the liquidus line than had been shown in the diagrams.

Vote of Thanks

The CHAIRMAN then proposed that a very hearty vote of thanks be accorded to the authors of the Papers for their extremely interesting communication, which was carried unanimously by acclamation.

Vibratory Effect on the Liquidus-Solidus Line

MR. ROWE said that with regard to the question of the equilibrium diagram shown upon page 3 of the Paper, the alpha solid solution line at practically 16 per cent. was one which he felt was quite right, and which had been definitely determined by other workers. It had been gradually pushed up as the years went on, and the full limit might not have been reached, but he did not think it was far off now. Regarding the difference between the liquidus and solidus lines, there was a good deal in the new theory that under a critical speed of vibration the liquidus and solidus would be merged into one line, but so far he had not observed anything in his experience of centrifugal casting, involving a good deal of vibratory effect, which led him to support the theory dogmatically. One of the proved features of centrifugal casting was that, due to the vibratory effect, the crystal size was kept extremely small. This was due to no other reason except the vibratory effects set up during the whole period of solidification, but that would not lead him to advance a theory that the solidus and liquidus did stand entirely in a straight line.

THE HOME SECRETARY gives notice that, in pursuance of his powers under Section 47 of the Workmen's Compensation Act, 1925, as extended by the Workmen's Compensation (Silicosis and Asbestosis) Act, 1930, and after a consultation with the industries concerned, he proposes to amend Paragraph 12 of the Silicosis and Asbestosis (Medical Arrangements) Scheme, 1931, which provides for the initial medical examination of workmen newly engaged for employment in occupations included in the first schedule to the scheme. Copies of the draft amending scheme can be obtained on application to the Industrial Division, Home Office, Whitehall, S.W.1.

Genuine Cold Blast Pig Iron ———

Brands:

DUD·L.N.F'ces·DUD,
GRAZEBROOK,
LOWMOOR C.B.

———the best insurance against defective castings

THE EARL OF DUDLEY'S ROUND OAK WORKS, LTD.,
BRIERLEY HILL, STAFFS.
Brand: "DUD·L.N.F'ces·DUD"

M. & W. GRAZEBROOK,
LIMITED,
DUDLEY, WORCS.
Brand: "GRAZEBROOK"

THE LOW MOOR IRON
CO., LTD.,
NEW WORKS, LOW MOOR,
BRADFORD - YORKSHIRE.
Brand: "LOWMOOR C.B."

MAKERS OF GENUINE COLD BLAST PIG IRON

RAW MATERIALS—PRICE LIST

(Wednesday, July 4, 1934)

COPPER

	£	s.	d.
Standard cash	30	7	6
Three months	30	15	0
Electrolytic	33	10	0
Tough	32	10	0
Best selected	33	0	0
Sheets	60	0	0
India	43	5	0
Wire bars	34	5	0
Ingot bars	34	5	0
H.C. wire rods	36	15	0
Off. av. cash, June	32	3	9
Do., 3 mths., June	32	10	5 5/8
Do., Sttlmnt., June	32	3	9 1/2
Do., Electro, June	35	10	7 1/2
Do., B.S., June	35	3	7 1/4
Do., wire bars, June	35	14	4 3/4
Solid drawn tubes			10d.
Brazed tubes			10d.
Wire			6 1/2d.

BRASS

Solid drawn tubes	9d.
Brazed tubes	11d.
Rods, drawn	8 3/4d.
Rods, extd. or rlld.	4 1/2d.
Sheets to 10 w.g.	7 1/4d.
Wire	7 3/4d.
Rolled metal	7d.
Yellow metal rods	4 1/2d.
Do. 4 × 4 Squares	5 3/4d.
Do. 4 × 3 Sheets	5 3/4d.

TIN

	£	s.	d.
Standard cash	228	5	0
Three months	227	15	0
English	228	5	0
Bars	230	5	0
Straits	228	15	0
Australian (nom.)			—
Eastern	228	15	0
Banca	229	5	0
Off. av. cash, June	226	19	9 6/7
Do., 3 mths., June	226	3	6 1/2
Do., Sttlmt., June	226	18	9 1/2

SPELTER

	£	s.	d.
Ordinary	13	17	6
Remelted	14	5	0
Hard	11	5	0
Electro 99.9	16	10	0
English	14	7	6
India	13	5	0
Zinc dust	16	15	0
Zinc ashes	3	2	6
Off. aver., June	14	7	1
Aver. spot, June	14	4	9 2/7

LEAD

	£	s.	d.
Soft foreign ppt.	10	15	0
Empire (nom.)	11	2	6
English	12	10	0
Off. average, June	11	3	0 11/14
Average spot, June	11	1	0 9/16

ALUMINIUM

Ingots	£100 to £105
Wire	1/1 to 1/9 lb.
Sheet and foil	1/2 to 2/9 lb.

ZINC SHEETS, &c.

	£	s.	d.
Zinc sheets, English	23	5	0
Do., V.M. ex whse.	22	2	6
Rods	28	0	0

ANTIMONY

	£	s.	d.	£	s.	d.
English	40	0	0 to	43	0	0
Chinese, ex-whse.				33	0	0
Crude				24	10	0

QUICKSILVER

	£	s.	d.	£	s.	d.
Quicksilver	11	2	6 to	11	10	0

FERRO-ALLOYS AND STEEL-MAKING METALS

Ferro-silicon—	
25%	£8 17 6
45/50%	£13 0 0
75%	£18 7 6
Ferro-vanadium—	
35/50%	12/8 lb. Va.
Ferro-molybdenum—	
70/75% carbon-free of Mo.	5/6 per lb.
Ferro-titanium—	
23/25% carbon-free	9d. lb.
Ferro-phosphorus, 20/25%	£14 10 0
Ferro-tungsten—	
80/85%	3/3 lb.
Tungsten metal powder—	
98/99%	3/6 lb.
Ferro-chrome—	
2/4% car.	£29 15 0
4/6% car.	£23 0 0
6/8% car.	£21 12 6
8/10% car.	£21 12 6
Ferro-chrome—	
Max. 2% car.	£36 0 0
Max. 1% car.	£38 15 0
Max. 0.70% car.	£42 0 0
70%, carbon-free	10d. lb.
Nickel—99.5/100%	£200 to £205
"F" nickel shot	£180 0 0
Ferro-cobalt, 98/99%	5/3 lb.
Metallic chromium—	
96/98%	2/5 lb.
Ferro-manganese (net)—	
76/80% loose	£10 15 0 to £11 5 0
76/80% packed	£11 15 0 to £12 5 0
76/80% export (nom.)	£9 15 0
Metallic manganese—	
94/96% carbon-free	1/2 lb.

Per ton unless otherwise stated.

HIGH-SPEED TOOL STEEL

Finished bars, 14% tungsten	2s. 0d.
Finished bars, 18% tungsten	2s. 9d.

Per lb. net, d/d buyers' works.

Extras—	
Rounds and squares, 3 in. and over	4d. lb.
Rounds and squares, under 1/2 in. to 1/4 in.	3d. lb.
Do., under 1/4 in. to 1/16 in.	1/- lb.
Flats, 1/4 in. × 1/4 in. to under 1 in. × 3/8 in.	3d. lb.
Do., under 1/4 in. × 1/4 in.	1/- lb.
Bevels of approved sizes and sections	6d. lb.

Bars cut to length, 10% extra.

SCRAP

	£	s.	d.	£	s.	d.
South Wales—						
Heavy steel	2	14	0 to	2	15	0
Bundled steel and shrngs.				2	7	6
Mixed iron and steel				2	10	0
Heavy cast iron	2	7	6 to	2	8	6
Good machinery	2	10	0 to	2	12	6
Cleveland—						
Heavy steel	2	7	6 to	2	10	0
Steel turnings				1	17	6
Cast-iron borings				1	7	6
Heavy forge				2	10	0
W.I. piling scrap				2	5	0
Cast-iron scrap	2	10	0 to	2	13	6
Midlands—						
Light cast-iron scrap				2	7	6
Heavy wrought iron				3	0	0
Steel turnings, f.o.r.				1	13	0
Scotland—						
Heavy steel	2	10	0 to	2	11	3
Ordinary cast iron	2	11	0 to	2	12	6
Engineers' turnings	1	19	0 to	2	0	0
Cast-iron borings				2	0	0
Wrought-iron piling	2	10	0 to	2	11	3
Heavy machinery				2	15	0

London—Merchants' buying prices, delivered yard.

	£	s.	d.
Copper (clean)	25	0	0
Brass	18	0	0
Lead (less usual draft)	10	0	0
Tea lead	7	5	0
Zinc	9	0	0
New aluminium cuttings	69	0	0
Braziery copper	22	0	0
Gunmetal	23	10	0
Hollow pewter	145	0	0
Shaped black pewter	110	0	0

PIG-IRON

N.E. Coast (d/d Tees-side area)—	
Foundry No. 1	70/-
Foundry No. 3	67/6
,, at Falkirk	67/3
,, at Glasgow	70/3
Foundry No. 4	66/6
Forge No. 4	66/6
Hematite No. 1	68/-
Hematite M/Nos.	67/6
N.W. Coast—	
Hem. M/Nos. d/d Glas.	72/6
,, d/d Birm.	84/6
Malleable iron d/d Birm.	115/-
Midlands (d/d Birmingham dist.)—	
Staffs No. 4 forge	67/-
,, No. 3 fdry.	71/-
Northants forge	63/6
,, fdry. No. 3	67/6
,, fdry. No. 1	70/6
Derbyshire forge	67/-
,, fdry. No. 3	71/-
,, fdry. No. 1	74/-
Scotland—	
Foundry No. 1, f.o.t.	72/6
,, No. 3, f.o.t.	70/-
Hem. M/Nos. d/d	71/-
Sheffield (d/d district)—	
Derby forge	64/6
,, fdry. No. 3	68/6
Lincs forge	64/6
,, fdry. No. 3	68/6
E.C. hematite	80/6
W.C. hematite	83/6
Lancashire (d/d eq. Man.)—	
Derby fdry. No. 3	74/-
Staffs fdry. No. 3	74/-
Northants fdry. No. 3	72/6
Cleveland fdry. No. 3	74/-
Dalzell, No. 3 (special)	102/6 to 105/-
Glengarnock, No. 3	82/6
Clyde, No. 3	82/6
Monkland, No. 3	82/6
Summerlee, No. 3	82/6
Eglinton, No. 3	82/6
Gartsherrie, No. 3	82/6
Shotts, No. 3	82/6

FINISHED IRON AND STEEL

Usual district deliveries for iron; delivered consumer's station for steel.

	£	s.	d.	£	s.	d.
Iron—						
Bars (cr.)	9	12	6 to	9	15	0
Nut and bolt iron	7	10	0 to	8	0	0
Hoops	10	10	0 and up.			
Marked bars (Staffs) f.o.t.				12	0	0
Gas strip	10	10	0 and up.			
Bolts and nuts, 3/4 in. × 4 in.				14	0	0
Steel—						
Plates, ship, etc.	8	15	0 to	8	17	6
Boiler plts.	8	2	6 to	8	10	0
Chequer plts.				10	7	6
Angles				8	7	6
Tees				9	7	6
Joists				8	15	0
Rounds and squares, 3 in. to 5 1/2 in.				9	7	6
Rounds under 3 in. to 1/2 in. (Untested)				8	12	0
Flats—8 in. wide and over				8	12	6
,, under 8 in. and over 5 in.				8	17	6
Rails, heavy	8	5	0 to	8	10	0
Fishplates	12	5	0 to	12	10	0
Hoops (Staffs)				9	7	0
Black sheets, 24g. (4-t. lots)				10	10	0
Galv. cor. shts. (,,)				13	0	0
Galv. flat shts. (,,)				13	10	0
Galv. fencing wire, 8g. plain				14	10	0
Billets, soft				5	10	0
Billets, hard	6	17	6 to	7	2	6
Sheet bars	5	0	0 to	5	5	0
Tin bars				5	0	0

PHOSPHOR BRONZE

Per lb. basis.

Strip	11d.
Sheet to 10 w.g.	12d.
Wire	12d.
Rods	11d.
Tubes	15d.
Castings	13d.

Delivery 3 cwt. free.
10% phos. cop. £30 above B.S.
15% phos. cop. £35 above B.S.
Phosphor tin (5%) £30 above price of English ingots.
C. CLIFFORD & SON, LIMITED.

NICKEL SILVER, &c.

Per lb.

Ingots for raising	7d. to 1/1
Rolled—	
To 9 in. wide	1/1 to 1/7
To 12 in. wide	1/1 1/2 to 1/7 1/2
To 15 in. wide	1/1 1/2 to 1/7 1/2
To 18 in. wide	1/2 to 1/8
To 21 in. wide	1/2 1/2 to 1/8 1/2
To 25 in. wide	1/3 to 1/9
Ingots for spoons and forks	7d. to 1/3 1/2
Ingots rolled to spoon size	10d. to 1/6 1/2
Wire round—	
to 10g.	1/4 1/2 to 1/11 1/2

with extras according to gauge.
Special 5ths quality turning rods in straight lengths, 1/3 1/2 upwards.

AMERICAN IRON AND STEEL

At Pittsburgh unless otherwise stated.

	Dols.
No. 2 foundry, Phila.	20.26
No. 2 foundry, Valley	18.50
No. 2 foundry, Birm.	14.50
Basic, Valley	18.00
Bessemer	20.76
Malleable, Valley	18.50
Grey forge, Valley	18.25
Ferro-mang. 80%, seaboard	85.00
O.-h. rails, h'y, at mill	36.37 1/2
Billets	29.00
Sheet bars	30.00
Wire rods	38.00
	Cents.
Iron bars, Chicago	1.90
Steel bars	1.90
Tank plates	1.85
Beams, etc.	1.85
Skelp, grooved steel	1.70
Steel hoops	2.10
Sheets, black, No. 24	2.65
Sheets, galv., No. 24	3.25
Wire nails	2.60
Plain wire	2.30
Barbed wire, galv.	3.00
Tinplates, 100-lb. box	$5.25

COKE (at ovens)

Welsh foundry	25/- to 30/-
,, furnace	20/-
Durham foundry	21/- to 25/-
,, furnace	17/6
Midlands, foundry	—
,, furnace	—

TINPLATES

f.o.b. Bristol Channel ports.

I.C. cokes	20×14 per box	17/3 to 17/6
,,	28×20 ,,	34/6 to 35/-
,,	20×10 ,,	24/9 to 25/-
,,	18 3/4×14 ,,	18/- to 18/1 1/2
C.W.	20×14 ,,	15/6
,,	28×20 ,,	32/6
,,	20×10 ,,	22/-
,,	18 3/4×14 ,,	15/6

SWEDISH CHARCOAL IRON & STEEL

	£	s.	d.	£	s.	d.
Pig-iron	6	0	0 to	7	0	0
Bars-hammered, basis	16	0	0 to	16	10	0
Bars and nail-rods, rolled, basis	15	15	0 to	16	0	0
Blooms	10	0	0 to	12	0	0
Keg steel	30	0	0 to	31	0	0
Faggot steel	18	0	0 to	23	0	0
Bars and rods dead soft, st'l	10	0	0 to	12	0	0

All per English ton, f.o.b. Gothenburg.
[Subject to an exchange basis of Kr. 18.16 to £1.]

DAILY FLUCTUATIONS

Standard Copper (cash)

		£	s.	d.		
June	28 ..	31	7	6	dec.	1/3
,,	29 ..	31	5	0	,,	2/6
July	2 ..	31	5	0	No change	
,,	3 ..	30	8	9	dec.	16/3
,,	4 ..	30	7	6	,,	1/3

Electrolytic Copper

		£	s.	d.		
June	28 ..	34	15	0	No change	
,,	29 ..	34	5	0	dec.	10/-
July	2 ..	34	5	0	No change	
,,	3 ..	33	15	0	dec.	10/-
,,	4 ..	33	10	0	,,	5/-

Standard Tin (cash)

		£	s.	d.		
June	28 ..	226	5	0	inc.	17/6
,,	29 ..	225	12	6	dec.	12/6
July	2 ..	226	15	0	inc.	22/6
,,	3 ..	226	5	0	dec.	10/-
,,	4 ..	228	5	0	inc.	40/-

Tin (English ingots)

		£	s.	d.		
June	28 ..	227	0	0	inc.	15/-
,,	29 ..	226	10	0	dec.	10/-
July	2 ..	227	5	0	inc.	15/-
,,	3 ..	226	5	0	dec.	20/-
,,	4 ..	228	5	0	inc.	40/-

Spelter (ordinary)

		£	s.	d.		
June	28 ..	13	15	0	inc.	2/6
,,	29 ..	14	0	0	,,	5/-
July	2 ..	13	18	9	dec.	1/3
,,	3 ..	13	15	0	,,	3/9
,,	4 ..	13	17	6	inc.	2/6

Spelter (Electro, 99.9 per cent.)

		£	s.	d.		
June	28 ..	16	7	6	inc.	2/6
,,	29 ..	16	12	6	,,	5/-
July	2 ..	16	11	3	dec.	1/3
,,	3 ..	16	7	6	,,	3/9
,,	4 ..	16	10	0	inc.	2/6

Zinc Sheets (English)

		£	s.	d.		
June	28 ..	23	5	0	No change	
,,	29 ..	23	5	0	,,	,,
July	2 ..	23	5	0	,,	,,
,,	3 ..	23	5	0	,,	,,
,,	4 ..	23	5	0	,,	,,

Lead (English)

		£	s.	d.		
June	28 ..	12	15	0	No change	
,,	29 ..	12	15	0	,,	,,
July	2 ..	12	15	0	,,	,,
,,	3 ..	12	10	0	dec.	5/-
,,	4 ..	12	10	0	,,	,,

A COMPARISON OF SCRAP PRICES

Prices of Heavy Steel Scrap (Delivered) in the Principal Districts at the Beginning of Each Month in the Years 1929–1934.

Year.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Yearly average.
	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.
Scotland—													
1929	3 5 6	3 7 6	3 12 6	3 15 0	3 15 0	3 15 0	3 15 6	3 16 0	3 17 6	3 15 0	3 12 6	3 10 6	3 13 1½
1930	3 9 0	3 7 6	3 5 0	3 5 0	3 0 6	2 15 0	2 12 0	2 10 0	2 13 3	2 10 0	2 10 0	2 10 0	2 17 3½
1931	2 7 6	2 7 6	2 5 0	2 0 0	1 17 6	1 17 6	1 17 6	1 17 6	1 17 6	1 15 0	2 0 0	2 2 6	2 1 0½
1932	2 2 6	2 2 6	2 0 0	1 17 6	1 17 6	1 17 6	1 15 0	1 15 0	1 12 6	1 13 0	1 12 6	1 15 0	1 16 9½
1933	1 15 0	1 17 6	1 18 6	1 18 9	1 18 0	1 17 6	1 18 9	2 0 0	2 2 6	2 5 0	2 7 6	2 8 9	2 0 7½
1934	2 8 9	2 14 3	2 13 0	2 13 0	2 12 0	2 10 0	—	—	—	—	—	—	—
North-East Coast—													
1929	3 0 0	3 2 6	3 3 6	3 3 6	3 3 6	3 5 0	3 5 0	3 5 0	3 5 0	3 6 6	3 5 0	3 3 6	3 4 0
1930	3 3 6	3 3 6	3 2 0	3 0 0	2 17 6	2 10 0	2 10 0	2 7 6	2 7 6	2 7 6	2 5 0	2 6 0	2 13 4
1931	2 6 0	2 6 0	2 5 0	2 5 0	2 2 6	2 0 0	1 17 6	1 17 6	1 17 6	1 17 6	1 17 6	2 2 6	2 1 2½
1932	2 0 0	2 0 0	1 15 0	1 15 0	1 15 0	1 15 0	1 15 0	1 15 0	1 15 0	1 12 6	1 15 0	1 17 6	2 15 10
1933	2 0 0	2 0 0	2 5 0	2 0 0	1 15 0	1 17 6	2 2 6	2 2 6	2 3 6	2 5 0	2 7 6	2 7 6	2 2 2
1934	2 10 0	2 16 0	2 10 0	2 7 6	2 7 6	2 10 0	—	—	—	—	—	—	—
South Wales—													
1929	3 8 6	3 10 6	3 15 0	4 0 0	4 0 0	3 18 0	3 17 6	3 17 6	3 15 0	3 15 0	3 12 6	3 7 6	3 14 9
1930	3 7 6	3 6 0	3 6 0	3 4 0	3 2 6	2 17 6	2 16 0	2 15 0	2 14 9	2 12 6	2 5 0	2 18 3½	
1931	2 5 0	2 7 6	2 7 6	2 7 6	2 5 0	2 2 6	2 0 0	2 0 0	1 18 0	2 2 6	2 5 0	2 7 6	2 4 0
1932	2 6 6	2 6 0	2 5 0	2 2 6	2 2 0	1 19 0	1 17 6	1 18 6	1 18 0	1 18 0	1 17 6	1 18 0	2 0 8½
1933	2 0 0	2 1 6	2 4 0	2 3 6	2 3 6	2 3 0	2 5 0	2 5 0	2 8 0	2 10 0	2 10 0	2 10 0	2 5 3½
1934	2 10 0	2 16 3	2 15 9	2 13 9	2 14 3	2 15 0	—	—	—	—	—	—	—

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(Founded 1838)
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